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A Merger By Any Other Name? Empirical Evidence of the
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Aisha Rafiqui-Masroor

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Kenneth D. Boyer
Major Professor's Signature

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A MERGER BY ANY OTHER NAME? EMPIRICAL EVIDENCE OF THE ANTI-COMPETITIVE EFFECTS OF DOMESTIC AIRLINE ALLIANCES

By

Aisha Rafiqui-Masroor

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ABSTRACT

A MERGER BY ANY OTHER NAME? EMPIRICAL EVIDENCE OF THE ANTICOMPETITIVE EFFECTS OF DOMESTIC AIRLINE ALLIANCES

By

Aisha Rafiqui-Masroor

In this paper we empirically investigate the behavior of the three airline alliances that were announced in early 1998 among the six most dominant carriers in the domestic airline industry. These alliances were announced at a time when antitrust law and regulatory concern made mergers between large and financially successful domestic carriers impossible. A natural question was therefore whether these alliances were a second best strategy: had they allowed these carriers to realize cost synergies that were so far being forfeited by expected antitrust intervention, or had they been a source of market power and served as a loophole in current antitrust law?

Starting with the premise that the motivation for the formation of these alliances would be reflected in their long-term fare behavior, strong evidence of the exercise of market power was found in all three cases. Though the timing of the fare responses highlighted some differences between the individual alliances, the uniformity of results supports the generalization of arguments against each of these arrangements.

This paper also presents strong evidence that airport dominance (a familiar source of market power in the airline industry) was greatly enhanced due to the formation of

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these alliances. Finally, division of the full sample into important sub-samples revealed that the increased market power of the Delta-United and Northwest-Continental alliances was derived from a reduction in the travel options available to travelers. For the US Airways-American alliance, demand complementarities or multi-market contact were more important for the realization of increased market power.

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Chapter 1. The Evolution of the Airline Industry: From Mergers to Alliances

This chapter briefly traces out the events taking place in the post deregulation airline industry that played major roles in the state of competition there. Beginning with the competitive impact of deregulation of this industry in 1978, this chapter ends with a discussion of the industry's current characteristic of increasing cooperation between carriers.

1.1 The Post Deregulation Years

The Airline Deregulation Act of 1978 deregulated the U.S. airline industry through the adoption of a gradual system of deregulation. Part of this process was the governance of the industry by the Department of Transportation (DoT) from 1985 to 1988. During this period, the DoT assuming contestability,[1] permitted many airline mergers.[2]

A *merger wave* in this industry thus took place in the mid 1980's as larger carriers began to acquire smaller ones, especially those that could provide substantial feed traffic to their designated hubs.[3] This enabled the larger carriers to extend their network and scale of operations. Many airlines abandoned smaller and more competitive markets in favor of consolidating their operations into regional hubs and city-pair markets where

[1] Contestability of airline markets has since been rejected. See for instance Hurdle, et. al (1989), Hurdle (1989), Levine (1987), Call and Keeler (1985) and Graham, Kaplan and Sibley (1983).

[2] Most mergers took place in 1985-86. In 1986 alone, 14 airline mergers were approved by the Department of Transportation. Some of these mergers were justified under the failing firm clause of the Merger Guidelines. Clougherty (2002) explains the favorable antitrust review received by some cross-national domestic airline mergers with that regulators may have considered their international competitive effects.

they could function as oligopolies, or even monopolies. This is not to claim that this was their prime motive: cost efficiencies possible through economies of density in a hub based network arrangement have been documented.[4]

Deregulation not only gave freedom of entry, but also of exit: along with an increase in acquisitions through mergers in the period immediately after deregulation, there were a large number of bankruptcies as well.[5] This widespread and rapid entry and abandonment following deregulation was not checked by the Department of Transportation and it helped carriers realize dominance at their designated hubs, resulting in the creation of *fortress hubs*. There is evidence that during this period of increasing consolidation of the industry, gate constraints and slot controls,[6] already genuine physical constraints at some of the most important airports in the country, began to be used as tools by the 'dominant carriers' to compete with rival carriers.[7] Dominant carriers were able to provide better flight frequency and/or flight convenience and inhibit other firms from obtaining landing slots, thereby impeding their entry and expansion in major markets.[8]

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[3] Large *hub* airports are those (as defined in the U.S. Code) with at least 1% of total annual passenger enplanements. These hubs are not necessarily the same as the hubs designated by carriers. According to the code, thirty one airports qualify as hubs, while twenty one of these are airline-designated hubs.

[4] See for instance, Brueckner, Dyer and Spiller (1992) and Caves, Christensen and Tretheway (1984).

[5] The main reason for firm collapse would be its failure to adopt appropriate *yield management* techniques that allowed it to collect fares specific to the elasticity of the consumer. That is, uniform pricing practices prevented many carriers from achieving minimum load factors.

[6] A gate is a physical asset at an airport. A slot refers to the right to land or takeoff from an airport at a certain time of the day.

[7] A carrier is 'dominant' if its market share at an airport is greater than 50%. See U.S. General Accounting Office, GAO/01-518T.

[8] See U.S. General Accounting Office, GAO/01-518T.

1.2 The Introduction of Frequent Flyer Programs

The introduction of loyalty inducing programs is an important aspect of the post deregulation evolution of the airline industry. The Frequent Flyer Program was introduced by American Airlines in May 1981.[9] Under the *AAdvantage* program, members accumulated mileage and could redeem credit either though free/discounted travel or service upgrades. A week later, United Airlines responded by announcing its own Frequent Flyer Program. Within the next six months, six other carriers had joined in with similar programs of their own and competition had begun (especially among the major carriers) to offer the most lucrative Frequent Flyer Program.

What followed ranged from credits for free travel to promotional tie-ins with car rental agencies, hotels, cruise liners and credit cards. The Frequent Flyer Program therefore became an important tool for an airline to compete with rival carriers and to secure the demand of its most lucrative travelers.

The *'Principal-Agent Problem'* is the basis for the main criticisms of these programs. That is, these programs can induce choice distortions by the traveler if the person accumulating and receiving benefits due to firm choice (the *agent*) is not the entity paying the airfare (the *principal).*[10] The outcome is that the employee makes decisions to maximizes his/her own travel benefits rather than the profits of the firm paying the air fare.

In the airline industry, the Principal-Agent problem surfaces due to a number of reasons. First, the complexity of the award structure makes it difficult for the principal to categorically ascertain whether the agent has indeed made an inefficient carrier choice

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[9] Aviation Week & Space Technology, "American Establishes Travel Bonus Program" Page 41, May 18 1981.

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or to reclaim these awards from the agent. Of course if this were possible, the program would lose its effect on carrier choice.[11]

Second, the non-linearity of the award system encourages members to concentrate their travel with a single firm, even when this choice is sub-optimal. Third, a carrier's Frequent Flyer Programs is not only able to discourage firm entry (unless the entrant has a comparable route structure), it can also discourage a fare challenge from other rival carriers that already serve in many of the same markets. Fare competition initiated by a smaller rival carrier may not serve its purpose if, in order to avoid loss of their awards, Frequent Flyer Program members do not make a firm-choice switch. Switching costs are created as benefits are awarded only once a certain mileage threshold has been reached and also since after award redemption, the member is awarded some initial bonus miles.[12]

And finally, these programs can also encourage the agent to take indirect routings between trip origin and destination, as credit is given for each 'segment' traveled.[13] This means that the size of a carrier's network is of great importance: a wider network not only allows Frequent Flyer Program members more opportunities to accumulate credit, it also provides them with more destinations at which to redeem travel awards.

There is evidence that the above mentioned distortions were induced by the Frequent Flyer Program. For instance, a survey by Toh and Yu (1988) confirmed the potency of these programs: they found that program members believed in concentrating their travel with one program to maximize their travel reward accumulation. Stephenson and Fox (1987) found that travel managers were concerned not only with the inefficient

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[10] See Wall Street Journal, "Greed Gets Most Mileage Out of Airline Credits" October 10, 1985.
[11] See Levine (1987).
[12] For more on the features of Frequent Flyer Programs, see U.S. General Accounting Office, GAO /RCED-90-102.

carrier choices made by their traveling employees, but that these programs encouraged travelers to adopt longer itineraries to accumulate mileage, increasing their travel time and company expenses. The single most important management concern though was the effect of these programs on airfares.

1.3 The Need for International Airline Alliances

The first international airline alliance was formed in 1986 between Air Florida and British Island. And then in 1987, British Airways and United Airlines proposed a code-sharing alliance that was later exempted from Department of Transportation scrutiny. This set the stage for changes in bilateral agreements between countries and also paved the way for antitrust immunity for such agreements.

The 1990's are characterized as a decade of increasing cooperation among carriers, on both the international and domestic front. While cooperation had been a feature of the industry since its inception, most was technical in nature, that is, in the exchange, leasing and pooling of aircraft and aircraft parts, and in the maintenance of aircraft and engines. Interlining agreements had also developed due to the tight regulatory framework that confined carriers to operate within the boundaries of their state.

The 1990's were also a decade of rapid growth in demand for air travel between the United States and the rest of the world, particularly Europe, creating the need for carriers to find ways improve their global network strengths and also to remain competitive at home. However, restrictive bilateral air service agreements continued to

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[13] A 'segment' is defined as travel under a single flight number, so both direct and non-stop flights are

exist, creating immense legal, political and institutional constraints on mergers of carriers of different countries. Route authority restrictions prevented a single carrier to serve more than a handful of major international destinations. The response from major domestic carriers was the formation of strategic alliances with international partners that would allow them to expand in these markets.[14]

These major international alliances enjoyed substantial legal exemptions. For instance, some of the big international alliances enjoyed the freedom to set fares, to coordinate schedules, to cooperate on revenue pooling and on marketing. Effectively, these arrangements allowed two carriers to function as a single entity while enjoying low commitment burdens. An alliance between United Airlines and Air Canada and one between American Airlines and Canadian Air, enjoyed such antitrust immunity.

Once a carrier formed an alliance with its international counterpart, the firms aimed to project themselves as a single entity.[15] The strategy was to provide travelers with the sense and experience of 'seamless' service, whereby the passenger feels no difference in firm identity and service between trip origin and destination.

It would be in this decade that the Frequent Flyer Program gained even more importance as a device that would allow major carriers to stay ahead of their competitors.

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single segment flights while connecting flights provide the opportunity to accumulate more credit.

[14] These international alliances enjoyed antitrust immunity. For instance, the alliance between Northwest Airlines and KLM and between United Airlines and Lufthansa enjoyed antitrust immunity.

[15] Advertising and program promotion was done extensively with an alliance logo instead of individual ones. For instance, KLM and Northwest developed the *KLM-Northwest World Wide Reliability* logo, which incorporated the logos of both partners.

1.4 The Formation of Domestic Airline Alliances

The successes realized upon formation of international alliances were followed by domestic carriers pursuing similar arrangements at home. In early 1998, management at Northwest Airlines and Continental Airlines announced that a link-up was being planned: an extensive and integrated alliance, with the member firms code-sharing, merging their Frequent Flyer Programs, joining use of their lounge facilities and swapping equity.

Thus in late 1998, Northwest Airlines purchased a majority stake in Continental Airlines, despite a Department of Justice lawsuit challenging the acquisition.[16] This alliance was to involve Northwest purchasing 51% of the voting stock of Continental Airlines. But due to objections by the Department of Justice, the plan was scaled back to a 46% stock acquisition. However, members of both Northwest and Continental's Frequent Flyer Programs could claim award flights on the other carrier's system, both domestic and international. Code-sharing, (that is the practice of using an airline's two-letter code on another airline's flight) was permitted on limited (non-hub) routes.[17]

A broad marketing alliance was soon announced by American Airlines and U.S. Airways and this was to include a joining of their Frequent Flyer Programs and code-sharing between their regional partners. Frequent Flyer Program members could combine their (domestic) travel miles with those earned on their partner's flights, though mileage earned on the partner's flights would not qualify transfer. This alliance was announced in April 1998. By September of the same year, Delta Airlines and United Airlines had embarked on similar plans of their own, allowing their Frequent Flyer

[16] The Department of Justice did not seek a temporary injunction against the transfer of voting control to Northwest Airlines. The lawsuit was dismissed in January 2001 when Northwest agreed to divest all by 7% of its voting interest in Continental Airlines.

[17] This alliance was examined as a full merger and the 5% market share increase provision in the Merger Guidelines was used to limit the routes on which the two carriers could code-share.

Program members to claim award flights for domestic travel on the other partner's system. Both alliances would grant joint access to airport lounges.[18]

The institutional setting of domestic alliances was to be significantly different from that of international alliances. For one, antitrust immunity was not expected for domestic partnerships, though initially the level of integration planned had been significant. While the main motivation for international alliance formation had been to gain entry and to bypass ownership barriers, such constraints did not exist in domestic markets.

A diverse area of business was planned for domestic airline alliances. For instance, it was planned that it may include joint sales and marketing, joint purchasing and insurance, joint passenger and cargo flights, code-sharing,[19] block-spacing,[20] links between Frequent Flier Programs, management contracts, and joint ventures in catering, ground handling and aircraft maintenance.[21]

While an inherent feature of domestic alliances was the low commitment pressure on the member firms, these carriers placed emphasis on their longevity. Anecdotal evidence suggests that partner firms recognized alliances as being an important part of firm dynamics and an effective means of gaining a competitive edge over rivals. Thus, while the initial emphasis of contemporary alliances had been on marketing, eventually they seemed increasingly *strategic* in nature.

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[18] Both US Airways-American and Delta-United dropped their plans to code-share after the attention received by the Northwest-Continental code-sharing agreement.

[19] Code-sharing is the practice of using of an airline's two-letter code on another airline's flight. It allows a carrier to expand its network without substantial costs.

[20] Block-spacing is the purchase and marketing of a certain number of seats on another airline's flight.

[21] A joint venture is a separate and independent organization set up by the partners to carry out specific tasks.

While the discussion above points to the difference in both motivation and scope between domestic and international alliances, the various motivations for alliance formation between *domestic* carriers, were only *seemingly* diverse.[22] In each, the basic elements of the desire for firms to achieve either improved efficiency or greater market power, the two competing results possible due to alliance formation, can be identified.

First, given that the current regulatory climate toward domestic airline mergers is far different from what it was immediately following deregulation, it may have served as an important impetus to alliance formation between domestic carriers.[23] That is, while a merger between large and financially successful domestic carriers would not be feasible under current antitrust laws, domestic alliance formation among the country's largest carriers may have been a second best strategy for carriers who seek either cost synergies or market dominance. If either of these effects is realized, the carrier is able to achieve significant advantages over its rival carriers.[24] Rival firms, especially those that do not serve a comparable number of important markets, will be unable to compete or at the very least, will be placed at a significant disadvantage.[25] Also, alliance features such as code-sharing and mergers of Frequent Flyer Programs can play an important role in

[22] For instance, management at Delta Airlines and Continental Airlines have expressed that these alliances were formed in response to a need to increase shareholder value and to increase convenience for the consumers through the offer of a wider network, greater frequency etc. See The Avmark Aviation Economist, "Virtual Mergers Regulatory Headaches", May 1998.

[23] While domestic carriers are actively restrained from an outright merger with another domestic carrier, the United States Congress has authorized the Department of Transportation to impose a 30 day waiting period (extendable to 150 days for code-sharing alliances) before certain joint venture agreements, (including Frequent Flyer Program links) are finalized. The Department of Transportation also "has the authority to prohibit airline practices as unfair methods of competition if they violate antitrust principles, even if the practices do not constitute monopolization and attempted monopolization under the Sherman Act." For more on the designation of authority between the Department of Justice and the Department of Transportation and other aspects of federal oversight on the airline industry, see U.S. General Accounting Office, GAO/01-518T.

[24] See Boresntein (1989). Again, this advantage could be increased market power or improved efficiency.

[25] See for instance, U.S. General Accounting Office, GAO/RCED-90-102.

contributing toward passengers disregarding the distinct identity of the two partner firms.[26]

Second, major domestic carriers may have pursued alliance formation since the costs associated with an outright merger can easily eliminate any value that may have resulted from the agreement. For instance, increasing costs that partner carriers could face include customer service disruptions, costs of repainting the fleet, the costs of severance packages as the new firm tries to eliminate redundancies, wage increases due to any labor contract negotiations, etc. And this list of costs associated with an outright merger is rift with unusually high complexities.[27] Therefore a low commitment agreement among parties that is afforded through an alliance may be more desirable.[28]

The 'strategic paralysis' that can be expected to take place after a merger is one such complexity that merging firms need to contend with and that can have an impact on firm profitability due to higher costs. It refers to a time period during which the two merging firms are unable to stay on top of day to day strategic business decisions due to the distraction of the merger. In an industry where such strategic moves are an important part of their interaction with rival firms and where such a hiatus could easily be observed, this set back can have consequences that the new merged firm may find hard to recover from.

Third, and as noted earlier, competition between carrier's marketing programs (such as their Frequent Flyer Programs) had been growing soon after their introduction in

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[26] Other marketing practices also contribute to providing the traveler with the sense of 'seamless' travel and they include block spacing, franchising, schedule coordination, proximate placement of gates between connecting flights, etc.
[27] See Airline Business, McKinsey & Company, "Making Mergers Work." Page 110-114, June 2000.
[28] Rhoades and Lush (1997) present the general conditions for stability and duration of alliances. They find that less complex arrangements between carriers contribute favorably toward their stability and maintenance.

1981. We consider this as an important motivation for their eventual mergers.[29] In fact, soon after the introduction of the first Frequent Flyer Program in 1981, other airlines operating jet propulsion aircraft began to offer similar programs, with a trend toward each being competitively obligated to match the promotional offers of its major rivals.[30]

Fourth, there was a growing trend toward greater cost containment by the time the three alliances were announced in early 1998. This had translated into the major carriers having less control over their business travel segment, thus far a corner stone of airline industry revenues. In fact, results of a survey by Bender and Stephenson (1998) of both corporate travel managers and business travelers, support this. They found that cost cutting on the corporate travel side was being achieved by ensuring that employee travel was both necessary and economical and through the growing popularity of video conferencing.

Fifth, the absence of sufficient economies of scale in the airline industry has also been established in previous empirical literature, while evidence of the presence of economies of scope has been presented.[31] This is a second important cost based motivation for alliance formation on the domestic front. These scope economies are related to the size and structure of the partner carrier's networks. Also, Frequent Flyer Programs (and therefore allied Frequent Flyer Programs) are more effective marketing strategies when the partner carriers offer a large network over which points can be collected and redeemed. Also, with respect to the realization of economies of density, as

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[29] For instance, in November 1987, Delta Airlines introduced a mileage plan under which 1988 mileage would triple automatically. Most major carriers responded within weeks with similar incentives of their own. In January 1990, a Frequent Flyer award war took place between United and American Airlines when travel awards were to be distributed after only a few trips. Northwest, Continental, Delta, TWA followed with their own generous reward programs. See Wall Street Journal, "War to Win Frequent Flyer Sizzles" by Asra Q. Nomani, January 26th, 1990.
[30] See Hu, Toh and Strand (1988).

traffic volume increases on individual routes, higher load factors lead to lower costs. This increased traffic density could allow the use of a larger aircraft that could be operated at lower unit costs.

Thus, there is a diverse list of possible motivations that can explain and justify the formation of alliances among major domestic carriers. However, the ex-ante identification of the exact motivation for domestic alliance formation is not necessary since in each, the basic elements of the desire for firms to achieve either improved efficiency or greater market power, remain valid.

1.5 The Question of Interest and the Need for this Research

Alliances between the six most dominant carriers in the domestic airline industry were announced at a time when both academic and regulatory concern regarding the state of competition in this industry, including the use of anticompetitive means by major carriers to secure demand at major airports, was high.[32] Since an outright merger between large and financially stable carriers was impossible, a natural question was whether these arrangements were a second best strategy to an outright merger. Had they enabled these carriers to realize some cost synergies or was increased market power the dominant effect?

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[31] See Caves, Christensen and Tretheway (1984).

[32] While the Department of Justice did not file its complaint against the Northwest-Continental alliance until October 1998, regulatory concerns regarding these alliances had been presented by the General Accounting Office in written testimony before the U.S. Senate in June 1998. See U.S. General Accounting Office, GAO/T-RCED-98-215.

Improved efficiency could have been realized perhaps through economies of density and/or economies of scope.[33] These carriers could have realized cost savings due to the former if the agreement allowed them better market access and/or traffic feed, and due to the latter if the alliance partners re-configured their networks after alliance formation.[34]

On the other hand, increased market power could also have been realized. For each domestic alliance, the two marketing teams and their formerly individual marketing programs, had been major rivals. Now the former may have found a platform to make mutually beneficial strategic decisions and the latter may now be virtually indistinguishable to an important and lucrative demand segment. The promise of pooled program mileage may be sufficient to allow these firms increased control over this demand segment and the 'elbow-room' to raise fares.[35] In such, these alliances may have been a second best strategy to an outright merger between the carriers: they are permissible arrangements that allowed member firms greater market power, while maintaining the freedom that comes with a low commitment arrangement.

While these marketing alliances among the major domestic carriers received considerable attention in the press and in regulatory circles, so far there has been no in-depth empirical study of their competitive effects. Thus it remains to be seen whether

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[33] See Caves, Christensen and Tretheway (1984) on the importance of economies of density in the airline industry.

[34] It was the extensiveness of the agreement between Northwest and Continental Airlines that was at the heart of the belief in regulatory circles that network synergies may allow the realization of welfare improvement.

[35] The three major domestic alliances had announced their plan to code-share, a plan later dropped by US Airways-American as well as by Delta-United. Northwest and Continental Airlines had also responded to Department of Justice concerns by dropping code-sharing on seven hub to hub markets. Plans to code-share on domestic routes had also created problems for these carriers among their labor unions. For instance, Delta and United Airlines decided to forego code-sharing when Delta's pilot unions refused to consider it. Pilots at American Airlines had responded similarly. American Eagle and US Airways Express also had labor discontent.

each of these alliances allowed its member carriers the realization of forfeited cost synergies or of greater market power.

The answer to this question hold relevance for the business traveler (a cornerstone demand segment of airline industry revenues and profits), rival carriers (that may either benefit from the fare 'umbrella' provided to them, or be placed at an unfair advantage for instance, by being denied market entry), ticket purchasing firms (the *Agent*) as well as 'watchdog' agencies like the U.S. General Accounting Office and the Department of Justice.[36]

1.6 Layout of Paper

This chapter provided a narrative history of the evolution of the domestic airline industry, from the mega-mergers of the mid 1980's to the increasing cooperation between large carriers in the 1990's, including the eventual combination of previously distinct Frequent Flyer Programs. In the next chapter, the structural model is presented and empirical literature on both airline mergers and (international and domestic) airline alliances is reviewed. Chapter 3 begins the analytical query in order to determine the answer to the hypothesis of increased efficiency versus greater market power due to domestic alliance formation. In Chapter 4, the relation between each alliance event and

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[36] Currently, both the Department of Transportation and the Department of Justice are responsible for ensuring the working of competition in the airline industry, with the latter responsible for taking actions against mergers that may stifle competition. Thus the Department of Justice has the authority to initiate any proceedings against an acquisition proposal if it violates the Clayton Act, which applies to any merger or acquisition that may substantially lessen competition in a relevant market, or tend to create a monopoly. The Department of Justice also has the authority to enforce the Sherman Act, which prohibits unreasonable restraints of trade and attempts to establish and maintain monopoly power. See Clougherty (2002) who notes that since over 90% of U.S. airline revenue is domestic, the international competitive effects of domestic airline mergers should have less political-economic weight in this country than in other nations. Therefore, antitrust authorities will be primarily concerned with the domestic competitive effects of domestic airline mergers.

the changes in airport dominance that it affords, is examined. Chapter 5 focuses on some important route sub-samples and Chapter 6 bears the concluding remarks.

Chapter 2. The Structural Model and Empirical Review

The two main institutional arrangements that have had a profound effect on the airline industry in recent history have been the mergers that dominated the structural landscape of this industry immediately after deregulation and the more recent trend of alliance formation. While the motivations and institutional impact of these and other main events in the post-deregulation airline industry were documented in the previous chapter, here we will discuss the documented *empirical* impact of these important events. We begin though with a structural model of firm behavior that captures and defines our main hypothesis.

2.1 The Structural Model of Equilibrium

Our structural model of profit maximization captures both firm specific responses as well as inter-firm rivalry. Consider an airport-pair market in which there are two firm 'types', that is, alliance and rival firms, both producing a homogenous service.[37] The i^{th} firm's route (r) and time (t) specific output is q_{irt}. Total market output is therefore

$Q_t = \sum_{i=1}^{2} q_{irt}$.

The market inverse demand function is given by:

$$P_{rt} = D(Q_{rt}, X^d_{rt}, A^d_{rt}, \varepsilon^d_{rt}) \tag{2.1}$$

[37] This is an arguably inappropriate assumption for the airline industry. However, it is one that has been often adopted in its previous empirical literature.

where X^d_{irt} are the variables effecting demand, A^d_{irt} represents the vector of variables that affect a firm's (route and time specific) demand *due* to alliance participation or non-participation, as the case may be. ε^d_{irt} is the error term.

The firm level total cost function is dichotomized into:

$$C_{irt} = C(q^c_{irt}, X^c_{irt}, B^c_{irt}, \varepsilon^c_{irt}) \tag{2.2}$$

Where X^c_{irt} are the factors that affect firm costs, B^c_{irt} is a vector of variables that directly affect firm costs *due* to alliance participation or non-participation. ε^c_{irt} is the error term to capture the cost impact of time varying unobservable factors on firm costs. Note that X^d_{irt} and X^c_{irt} may also capture the impact of route specific measures that are time and firm invariant, for instance airport specific infrastructure constraints.

Given these demand and cost specifications, firm i's route and time specific profit function is:

$$\Pi_{irt} = D(Q_{rt}, X^d_{irt}, A^d_{irt}, \varepsilon^d_{irt})\, q_{irt} - C_{irt} \tag{2.3}$$

With Q_{rt} as the choice variable, the Cournot-Nash equilibrium is represented by the following first order condition that yields the market price:

$$P_{irt} = MC_{irt}(Q^c_{irt}, X^c_{irt}, B^c_{irt}, \varepsilon^d_{irt}) - (\partial P/\partial Q)\, q_{irt}\, \theta_{irt} \tag{2.4}$$

The introduction of a route subscript in equation 2.4 draws especial attention to the fact that fare behavior in the airline industry is expected to not only depend on firm identity and on the time period selected, but also on route specific characteristics. In this setting, equilibrium is achieved when each firm optimizes its output, given the output of the other firm.[38]

The standard Cournot model predicts that if the alliance firm restricts its output after the event, its rival firms will respond with an increase in their own output. However, rival firm response may be restricted *due* to their non-participation in the alliance. That is, for firms remaining outside the agreement, demand and/or costs may change (the former captured by A^{d}_{irt} and embedded in equation 2.4, the latter by B^{c}_{irt}) in the post-alliance period *due* to their non-participation. We therefore want to allow for the possibility of alliance and rival firm fare differentials, despite their producing a homogenous service.

In equation 2.4, $\theta_{irt} = (\partial q_j / \partial q_i)$, where $(j \neq i)$, and is the firm, route and time specific Conjectural Variations parameter, or according to Bresnahan (1989), is the index of "the competitiveness of oligopoly conduct." The Cournot solution corresponds to zero conjectural variation and if the firm behaves more collusively than Cournot, $\theta_{irt} > 0$. Conversely, $\theta_{irt} < 0$ depicts a more competitive state than captured by the Cournot setting. In an oligopolistic setting therefore, firm conduct can be inferred from its fare behavior. If price, rather than quantity is the choice variable, then Bertrand solution yields marginal cost pricing, that is, the same as under perfect competition. At the other extreme, (tacit) collusion between two (identical cost) firms with an aim to maximize their joint profits implies that $\theta_{irt}=1$.

In the Cournot model, the market price moves toward the competitive price if the number of firms is large enough. Then each firm realizes (approximately) zero profits and

[38] An alternative framework is when each firm views the output of the other firm as a function of its own

acts as a price taker. However, when firm products are differentiated, the firm no longer faces infinite demand elasticity at equal prices. This means that positive price cost margins are possible due to product differentiation.

Equation 2.4 can be re-written as:

$$[P_{rt} - MC_{irt} (Q_{irt}, X_{irt}, B^{c}_{irt}, \varepsilon^{d}_{irt})] / P_{rt} = [(1+ \theta_{irt}) MS_{irt}] \eta \tag{2.5}$$

Where MS_{irt} is firm i's (route and time specific) market share and $\eta = -(\partial Q_{rt}/ \partial P_{rt}) (P_{rt} / Q_{rt})$ is the (positive) price elasticity of market demand. Equation 2.5 shows that price is a (non-linear) function of marginal costs and a 'mark up' that is positively correlated with its market share, and that also depends upon the conjectural variations parameter. That is, an increase in either market share or the conjectural variations parameter will increase price.

Keeping with the accepted protocol of *new empirical industrial organization*, we proceed with that firm level marginal cost is not directly observable. Rather, the price-cost margins will be inferred from experiments of firm behavior.[39]

Writing out the model in terms of the Lerner Index (equation 2.5) shows that the spread between a firm's prices and its marginal costs (or the 'price distortion') will rise if its prices rise and its consumers adjust their demand downward only slightly. Thus low demand elasticity induces strong price distortions. That is, even when the firm increases its unit price, the corresponding demand response from its consumers is low: market

output decision.

[39] For more on the current framework of empirical oligopoly, see Bresnahan (1989).

share adjusts downward, but does not go to zero and there is a large monetary transfer from consumers to the firm.

We can also write firm *i*'s perceived elasticity of demand as:

$$\eta_{irt} = \eta / MS_{irt} (1+ +\theta_{irt}) \tag{2.6}$$

Equations 2.5 and 2.6 show that each firm's price-cost margin ratio is determined by the reciprocal of its perceived elasticity of demand. In the monopoly state (or with cartel formation in an oligopoly setting) this implies that the firm's own perceived price elasticity of demand is equal to the market elasticity η, otherwise $\eta_i > \eta$. In an oligopoly for instance, η_i may or may not equal η.

2.2 Efficiency versus Market Power- The Primary Hypothesis

Equation 2.4 captures the primary hypothesis of this paper: did the alliance firm's fare response indicate that it had realized an improvement in efficiency due to alliance formation, or had increased market power dominated?

Factors that directly influence the alliance firm's demand after alliance formation as well as those that can affect its costs, are embedded in this equation through A^d_{irt} and B^c_{irt}, respectively. Specifically, if the alliance firm realizes improved efficiency/cost synergies through alliance participation, lower marginal costs will lead to lower fares, at least beyond the short term and the price gap between alliance and rival firms will decrease in the period corresponding to alliance formation.

There are two potential sources of efficiency gains especially worth mentioning within the framework of domestic alliances: economies of density and economies of scope.[40] Substantial cost savings due to the former can be realized if increased market access and/or traffic feed can be achieved, which in turn depends on the degree of network integration between the partner carriers. And the latter, while relevant in the airline industry, will not be realized unless partner carriers re-configure their networks after alliance formation.[41]

However, if increased market power is the dominant outcome from alliance formation, alliance firm fares will be rising (through higher A^{d}_{irt}), ceteris paribus, and the price gap between alliance and rival firms will increase.[42]

To the extent that rival firms are able to take advantage of the umbrella of alliance firm fare increases, it will indicate a collusive environment (that is, $\theta_{irt} > 0$ in equation 2.4) and will translate into a post alliance price gap similar to the one before alliance formation.[43]

In summary, it is the direction of growth of alliance firm fares that will signal the dominance of either improved efficiency or of increased market power.[44] Even if some of both these effects are realized, the direction of change in their fares will indicate the

[40] See Caves, Christensen and Tretheway (1984) on the importance of economies of density (rather than economies of scale) in the airline industry.
[41] We assume that new entry does not take place in response to alliance fare decreases.
[42] This outcome can result either from the larger size of the 'new' firm, or through reduction in competition due to the elimination of a competitor. See for instance Borenstein (1990) who finds evidence of increased market power from the Northwest-Republic merger at its Minneapolis hub.
[43] We note that concerns regarding collusion the airline industry have been often raised and are augmented not only due to the dominance of key airports by a few carriers, but also due to the often documented fare implications of multi-market contact in the airline industry. Secondly, changes in fares and quantities are easily observable in this industry. Therefore alliance formation can potentially not only provide formerly competing carriers with a forum for a collusive stance, but a host of other factors pre-exist that create strong incentives for firms to abide by the terms of some (tacit) agreement. See Alam, Ross and Sickles (2001) on how a stable price relationship between firms can signal successful dynamic oligopolistic interactions.

dominant effect.[45] This then defines the test of the primary hypothesis of efficiency improvements versus increased market power from alliance formation and this exercise will be detailed and undertaken in the next chapter. First though, the more recent empirical literature on the main events that have shaped the post-deregulation airline industry is reviewed.

2.3 Previous Empirical Evidence

2.3.1 Airline Mergers and their Impact on Fares

The effects of the post-deregulation trend of growth by merger in the airline industry have been documented in a number of research papers. For instance, Borenstein (1990) aimed to uncover the effect of the 1986 merger of Northwest and Republic Airlines and TWA's acquisition of Ozark Airlines. This paper uses the same basic principles of our model of equation 2.4 and of our hypothesis of Section 2.2 where we presented that firm fare changes indicate the dominance of either improved efficiency (through lower B^{c}_{irt} in our equation 2.4) or increased market power (through a higher A^{d}_{irt}). In Borenstein (1990), a *relative fares* [46] *difference in differences* technique detects an empirical link between the event and increased market power in the Northwest-Republic merger case. And at the hub airports of TWA-Ozark, the paper shows that there was no systematic

[44] Evidence of increased market power was found by Borenstein (1990) for the Northwest-Republic merger of 1986 at its Minneapolis hub, and by Kim and Singal (1993) who examined fourteen airline mergers that took place during the airline merger wave in the mid 1980's.

[45] This reasoning assumes that alliance participation the only difference between the firms. Recall that to the extent that such participation creates sufficient product differentiation, fares may not have to be downward responsive to realized cost synergies.

[46] Relative fare is defined as the ratio of the fares of the merging carrier on its major hub airports, to average industry fares for routes of the same distance.

difference between the fares of this merged firm and that of other carriers operating in the same markets, at least in markets where the merged carrier faced competition.

The basic principles of our behavioral model of equation 2.4 and the d*ifference in differences* approach is also the method of choice in Kim and Singal (1993) who examine 14 airline mergers that took place between 1985 and 1988. First, *relative fare changes* are calculated between sample and control routes and between the two (before and after) time periods in order to determine whether the dominant effect was improved efficiency or increased market power. Results show that these mergers were associated with a 10% increase in airfares and that rival firms had followed with fare increases of their own, showing the dominance of increased market power from the mergers and the presence of the *umbrella effect*, respectively. Next, econometric estimation revealed a significant positive correlation between fare changes and changes in concentration for both merging and rival firms.

Farrell and Shapiro (1990) analyze horizontal mergers in a Cournot oligopoly and find that for a merger to lower prices, considerable economies of scale or learning need to be realized. McAfee, Simons and Williams (1992) show that when firms engage in spatial price discrimination, their equilibrium post-merger prices increase.

Boyer (1992) has shown that a merger results in a decrease in output in those markets where competition is eliminated and the resultant decrease in marginal cost of the merging firm causes *harm* to non-participating firms. This harm to rival firms is presented as a sufficient index of harm to social welfare. This model is one of oligopolistic interaction in which firms function in overlapping but related markets and where the good is homogenous but price charged depends on market conditions. The possibility of separate markets and of non-uniform pricing creates conditions for the absence of an *umbrella effect* for rival firms: there is an increase in competition even outside the core markets dominated by the merging firms where rival firms are placed at a price disadvantage, though not because of their inefficiency. The harm to consumers and to rival firms is sufficient to characterize the merger as harmful. The two important assumptions to reach this result are that firms in the industry have strengths in different markets (that is, they operate in different locations), and that they face capacity limits and inter-market connections.

2.3.2 The Fare Impact of Airport and/or Route Dominance

Borenstein (1989) has estimated the impact of route and airport dominance in the degree of market power exercised by the nine largest domestic carriers in the third quarter of 1987. After controlling for some important measures of quality and cost, results show that both route and airport market shares are relevant in determining the degree of market power afforded to a carrier: a 1% increase in the carrier's route market share is estimated to increase its fares by between 0.03% to 0.22%. The fare effect of airport dominance was also found to be strong, especially for high-end fares. Results show that a dominant carrier[47] charges 6% higher median and high-end fares and that smaller carriers were unable to benefit from the 'umbrella' created by the dominant carrier, a discrepancy explainable by marketing devices (such as Frequent Flyer Programs) that favor the dominant firm.

Evans and Kessides (1993) also sought to answer the same question: that of the impact of airport and route dominance on the ability of a dominant carrier to raise fares. Examining 1988 data for 22 carriers for the top 1000 most heavily traveled routes and using fixed-effects estimation, they found that while airport dominance does create substantial benefits for the carrier in allowing it to raise it fares, a result also noted by Borenstein (1989), no pricing power was found to derivable from route level dominance.

2.3.3 Frequent Flyer Programs

As noted earlier in Chapter 1, the 1980's trend in the airline industry of growth by merger was followed by the introduction of programs designed to allow carriers to achieve growth by capturing consumer loyalty. These programs allow the carrier to earn a disproportionate share of its net revenue from a specific passenger type. Specifically, it is the low fare/ high time valuation traveler that is their most important source of revenue. Given the recent interest by businesses to curtail their travel costs, benefits provided under a carrier's Frequent Flyer Programs became a vital means of achieving revenue growth for carriers operating in a tight economic environment.[48] They may even have been a way for carriers to realize increased load factors.[49] In any case, the programs served an important source of revenue growth.

Banerjee and Summers (1987) modeled Frequent Flyer Programs as collusion facilitating devices that allow firms to split the market and then charge higher fares from the price inelastic and time sensitive class of consumers. The creation of an artificial switching cost allows positive economic profits, as consumers may redeem their benefits only upon remaining loyal to the firm.

[47] Airport dominance refers to an airport market share of at least 50%.
[48] See for instance, Stephenson and Fox (1987).
[49] Load factor is defined as the ratio of the number of seats filled to the total number of seats on the aircraft. Higher load factors can lower fares through a lower X^{c}_{irt} in Equation 2.4, or even raise them through higher X^{d}_{irt}.

Through a two-firm (A and B), two-period (t=1,2) model they show that these programs can increase the payoffs to all participants in the game. The two firms produce a homogenous good at zero marginal costs and no fixed costs, compete at the price level (P^i_t) so that $0 \leq P^i_t \leq 1$ (where firm i is the price leader in the t^{th} period) and in the non-transferable coupons offered (C^A_2 and C^B_2). The coupons can be used for discounted travel in the second period. Prices are set sequentially in each period (P^A_1, P^B_1, P^A_2, P^A_2). The price leader in the first period is picked randomly and in period 2, the firm with the largest market share leads fare setting. Consumers have a reservation demand of 1 unit and a homogenous reservation price of 1. Each consumer makes a firm choice decision upon observation of both fares and coupons and maximizes his or her expected utility over the two periods.

First consider that the second period game is such that an equal proportion of coupons from each firm have been selected in the first period. Thus, in the second period the two firms evenly split the market. Their market shares are therefore, $\mu^A_1 = 1/2$ and $\mu^B_1 = 1/2$. If firm A is the price leader and it seeks to cooperate by not undercutting, then it will set P^A_2 such that $P^A_2 \leq 2C^A_2 + C^B_2$. If A sets $P^A_2 = 2C^A_2 + C^B_2$ (where $2C^A_2 + C^B_2 \leq 1$), then it seeks to enforce cooperation. While setting $P^A_2 > 1$ will lead to zero profits for A (as B will undercut), setting $P^A_2 = 1$ dominates setting $P^A_2 < 1$. This means that firm profits will be an increasing function of coupon size. Firms benefit from an increase in their rival's coupons as this deters undercutting. Thus when coupon size is sufficiently large, the firms split the market and the joint monopoly outcome results.

Second, consider the scenario that firm A had the larger market share in period 2 and is therefore the price leader. Once firm A's second period price is set (P^A_2), carrier B can set its fares such that each firm retains its first period consumer base. This implies a lower limit on firm B's second period fares ($P^A{}_2 - C^A < P^B{}_2 < P^A{}_2 + C^B$) if it desires greater profits. That is, while firm B could set a low price and capture the entire market, it does better to set a higher fare if the value of the coupons is high. Similarly, it is in the interest of firm A to set its second period fares such that firm B sets a moderate fare, allowing both to retain their first period customer base. Thus second period profits are an increasing function of the value of the coupons set in the first period. They show that an equilibrium is $C^A = 1 = C^B$, $P^A{}_1 = 1 = P^B{}_1$, $P^A{}_2 = 2 = P^B{}_2$.

This model shows that Frequent Flyer Programs allow firms to abandon incentives to undercut and start a price war. As long as each firm has the potential for significant positive profits in the second period, it is in its interest to share the market.

Cairns and Galbraith (1990) have shown that an incumbent firm offering a Frequent Flyer Program is able to create a barrier to entry despite zero cost advantages. It does so through the creation of an "artificial compatibility" among its own services, that is, by creating an incentive for the consumer to buy from a single firm. Offering a more attractive rebate program allows the incumbent to maintain positive profits as well as to deter entry. Even if the rival firm offers its own rebate program, the scope of the incumbent's network makes the valuation of its rebate program higher.

2.3.4 International Airline Alliances

Recent empirical work on international airline alliances has consistently noted their welfare improving effects. Brueckner's (2001) theoretical model shows that in interline markets, code-sharing will improve welfare through cost efficiencies achieved through cooperative pricing between the two partner carriers.[50] This benefit in interline city-pair markets will be greater than the increased market power in inter-hub markets, where competition will be reduced.[51]

If international alliance partners coordinate their operations to feed passenger traffic to each other's hub airports, it allows both partner firms to effectively enter new city-pair markets without any investment in new resources. Brueckner, Dyer and Spiller (1992) show that increased traffic density translates into economies of density.

Using a model similar to our equation 2.4, where the dominance of efficiency versus that of increased market power has divergent effect on fares, Park and Zhang (2000) present an empirical analysis of international airline alliances. They find that these partnerships generated additional passenger demand and lower equilibrium level fares. These welfare improvements were led by the cost reductions achieved after a reduction in the redundancies among partner firms, who integrated activities and linked networks. Overall, code-sharing among the partners allowed the realization of efficiencies and improved convenience for interlining passengers.

Similarly, Brueckner (2003) has examined the change in the interline fares paid by international passengers due to the effects of code-sharing and antitrust immunity. The results show that code-sharing between the carriers had the effect of reducing international interline fares 8%-17%, and that antitrust immunity reduced fares by 13% to 21%.

[50] Code-sharing is the practice of using of an airline's two-letter code on another airline's flight. It allows a carrier to expand its network without substantial costs and is a common feature of international airline alliances.
[51] That is, markets between the hub cities of the partners.

2.3.5 Domestic Airline Alliances

The formation of alliances in 1998 involving the six largest domestic carriers in the United States (which accounted for about 70% of the domestic airline traffic then) received attention in the press and raised concerns in regulatory circles of their potential anticompetitive effects. However, we are not aware of any empirical study that has examined the actual competitive impact from these three partnerships: the most recent academic and regulatory inquiry on the airline industry focus almost exclusively on international airline alliances. There were two exceptions.

First, in early 1999 the U.S. General Accounting Office presented an examination of the *likely* effects of the alliances formed between the big six domestic carriers, with a focus on the anti-competitive effects likely if all three were to also implement code sharing.[52] Overall, they found that with such a scope, all three alliances could have positive effects for consumers in terms of additional flight frequencies and points served but would likely harm new entrants and non-alliance carriers. It was recognized that if competition were reduced between the carriers once they entered the agreement, it would create competitive harm for consumers. The three alliances were not expected to stimulate demand for air travel, but to allow demand shifts away from non-alliance carriers.

The tabular analysis of this study was based on pre-alliance (1997) data and is therefore predictive. An accurate identification of the effects of these alliances should be based on the structural changes brought about by the event, using both pre and post alliance data. The conclusions of this study therefore remain to be empirically confirmed or refuted.

Second, Bamberger, Carlton and Neumann (2001) examined the code-sharing alliances between Northwest and Alaska Airlines (which began in 1995) and between Continental and America West Airlines (which began in 1994). This paper is part of their testimony in favor of these two alliances.[53]

Since code-sharing by the carriers in question took place on only a handful of routes, fare (and traffic) changes were examined on routes on which code-sharing had taken place (the treatment group) versus those on which it had not (the control group). Specifically, the treatment group of routes included those city pairs on which a code-sharing agreement converted a potential interline flight into a code-shared flight. Using the first difference method of estimation, they found that the growth in the price gap on sample versus control routes was negative.[54]

Thus while their method is compatible with our model of equation 2.4, where improved efficiency and increased market power have opposing effects on fares, alliance firm fare behavior is not examined and the question of the realization of efficiency versus market power at the firm level, remains unanswered.

2.4 Synopsis and Conclusion

The hypothesis of the attainment of efficiency improvements following domestic alliance formation versus the attainment and exercise of market power on important domestic routes was explicitly presented in this chapter through a price equation. This model has been the basis of empirical work in the airline industry for both merger and

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[52] U.S. General Accounting Office, RCED-99-37.

[53] Testimony was presented by Carlton and Lexecon Inc. and was sponsored by Northwest and Continental Airlines.

alliance analysis and shows how the two competing effects possible from mergers and alliances, are nested in profit maximization theory. This model then forms the basis of an examination of alliance fare behavior that will be undertaken in the next chapter.

[54]For more on panel data methods, see Wooldridge (2002).

Chapter 3. Alliance Formation: Efficiency versus Market Power

In the previous chapter it was discussed that within the general framework of Bresnahan (1989) improvements in efficiency versus the exercise of market power have divergent effects on firm fares. Thus the primary hypothesis is whether alliance fare behavior indicates that they realized higher efficiency/cost synergies after alliance formation or did greater market power dominate? Note that the analysis of the competitive impact of these alliances assumes that the two partner carriers behave as if they had merged.[55]

3.1 The Price Equation

A price equation that represents a reduced form from the previously specified structural model of Chapter 2 (equation 2.4) is specified and it is assumed that the equilibrium price is affected by both endogenous and exogenous variables. In equation 2.4, it was noted that the price charged by a carrier on a route depends on factors that influence demand and supply. The assumption of unchanged supply factors means that the price equation can be thought of as a reduced form specification, with demand characteristics included as explanatory variables. Thus the results of this chapter, given the previously specified structural model in Chapter 2, will be seen as tests of the primary hypothesis.

[55] An approach that follows the literature on airline alliances. See for instance Brueckner (2003) and Bamberger, Carlton and Neumann (2001).

A log transformation of equation 2.4, where price is a non-linear function of the marginal cost, plus a markup term (which in turn is shown to depend on market share and the conjectural variations parameter) provides the linear approximation for estimation:

$$\mathrm{Ln}\ P_{irt} = \mathrm{Ln}\ MC_{irt}\ (Q_{irt}, X_{irt}, B^{c}_{irt}, \epsilon_{irt}) - \mathrm{Ln}\ [\ 1 + (1/\eta)\ \theta_{irt}\ MS_{irt}\ ] \tag{3.1}$$

Equilibrium fares are estimated after replacing the last term of equation 3.1 by a linear function of other factors affecting fares in the airline industry, shown by the vector X_{irt}. Therefore equation 3.1 is rewritten as:

$$\mathrm{Ln}\ P_{irt} = \mathrm{Ln}\ MC_{irt}\ (Q_{irt}, X_{irt}, B^{c}_{irt}, \epsilon_{irt}) + X_{irt} \tag{3.2}$$

Again, the accepted protocol in *new empirical industrial organization* is that firm level marginal cost is not directly observable. The basic model is:

$$\ln P_{irt} = X_{irt}\,\beta + U_{irt} \tag{3.3}$$

where X_{irt} is a vector of regressors, including a constant. Equation 3.3 is the price equation that will be estimated on the balanced panel and where i = 1… n (subscript for firm), r = 1,…n (subscript for route) and t = 1,2,3,4 (subscript for quarter). The dependent variable is (the log of) the one way average fare of carrier *i* on route *r* in quarter *t*.[56] It is therefore half the average coach class fare paid for a round trip during a particular quarter, outbound from the base airport.

[56] For the alliance, this is the average fare of the two alliance members for each identical itinerary.

3.2 Explanatory Variables and Expected Signs

To test the primary hypothesis of the dominance of efficiency versus market power from alliance participation, the empirical analysis relates the log of average fares ($lfare_{irt}$) to alliance formation and to other variables that form the vector of structural variables ($\mathbf{X}_{irt}$ in equation 3.2). Thus the price equation contains a constant plus:

1. An Alliance Participation dummy variable ($ALLY_{irt}$) that indicates whether the firm is a member of the alliance in question. The sign and magnitude of this explanatory variable is the main focus of the empirical analysis of this paper as it will provide the answer to the primary hypothesis. Specifically, a negative coefficient on this dummy variable ($ALLY_{irt} < 0$) means that alliance formation was associated with lower average fares, or that the event generated efficiency gains. Conversely, a positive dummy variable ($ALLY_{irt} > 0$) is evidence of the realization of increased market power from alliance participation.

It is defined as one when the firm is a partner of the domestic alliance in question, and zero otherwise. (Expected Sign: Indeterminate).

2. A Cost Component. The structural model of equation 2.4 shows that the equilibrium price also depends on a cost component. In air travel, generally the most important cost component of a trip is its distance, that is the non-stop mileage (in statute miles/ 5,280 feet) between the origin and destination airports, and is taken in logs ($lDIST_r$). There is also a direct relation between the distance between two airports and the lack of good substitute modes of transportation available to the consumer, and therefore demand for air travel. That is, substitute modes of transportation become less

attractive for longer distance travel and so firms may realize greater fare leverage on longer distance routes. However, costs should not increase with distance in a linear fashion.[57] (Expected Sign: Positive. Expected Elasticity: Less than one).

3. Time Dummy Variables. T-1 time dummy variables capture the effects of macroeconomic factors on the dependent variable. Given that air travel is highly pro-cyclical, the inclusion of time intercepts permits control of the seasonal influences on fares. Their exclusion would force one to assume that the change in the dependent variable ($lfare_{irt}$) is due to alliance participation (captured by $ALLY_{irt}$) when in fact it may have actually been due to external, economy-wide effects.

4. A measure of competition. The count of the number of rival firms operating on a given route 'r' at time 't' will proxy the degree of competition there ($Nfirms_{irt}$). (Expected Sign: Negative).

5. A dummy variable to identify routes on which at least one endpoint is gate constrained or slot controlled ($Gate/Slot_r$). It takes a value of 1 on airports that are gate constrained or slot controlled, and 0 otherwise.[58]

Slot controlled airports are those where the Federal Aviation Administration has, since 1969, placed limits on take off and landings in order to minimize flight delays. While these slots were initially allocated in 1985, the Department of Transportation had allowed carriers to buy them from and sell them to other carriers. However, the DoT had

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[57] Shorter distance markets generally tend to have a higher per mile fare than longer distance ones.

maintained the ownership of 5% of the slots at these four airports, and later distributed them through lottery to those carriers that had few or no slots. Many of these were carriers that subsequently went out of business resulting in the increase in slot ownership by a few firms.[59]

Similarly, gate constrained airports are those where gate facilities are limited through long term and exclusive-use leases. Again, these leases tend to be owned by larger carriers.

In terms of the impact of these time invariant constraints on the dependent variable, note that when the ownership of these factors is controlled by one or a few firms, market demand will be more easily concentrated with a few firms, an affect captured through a higher X^d_r in equation 2.4.[60] These firms may refuse to sell or lease these factors to carriers wanting to expand at these airports, imposing higher costs on these rivals, an effect captured through a higher X^c_r in equation 2.4. For firms owning the majority of these scarce resources at an airport, positive fare changes represent the extraction of market power and for those who do not, the scarcity rents due to non-ownership of sufficient airport gates and slots. Both these conditions create an expectation for a positive parameter estimate for this variable. (Expected Sign: Positive).

6. A dummy variable to indicate if at least one endpoint airport is geographically *'isolated'*. This is the second route specific and time invariant structural factor that is

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[58] Scarcity rents can be expected to *accrue* to firms that own these factors. Evans and Kessides (1993) find airport capacity constraints augment a carrier's market power. See Appendix C for a list of the gate and slot constrained airports within our route sample
[59] See U.S. General Accounting Office, GAO/RCED-97-4 on slot ownership at dominated airports.
[60] See Morrison and Whinston (2000), who find that much of the fare difference between hub and non-hub airports can be accounted for by the fact that low cost carriers avoid congested airports.

important to consider in its effect on our dependent variable. It takes on a value of 1 for routes on which at least one endpoint airport is 'isolated' and is 0 otherwise.

At secondary airports, costs tend to be low since they have lower Passenger Facility Charges (PFCs). Here, delay costs should also be lower due to lack of congestion problems.

This variable proxies for the rents accruing to carriers serving such 'isolated' airports, an effect captured by a higher X^d_r in terms of the structural model and equation 2.4. It also proxies for the constraints faced by firms in expanding and competing with incumbent firms in such a metropolitan area. The costs of these firms will be higher due to this constraint, captured by a higher X^c_r in equation 2.4. The expected sign on the $ARPT_r$ coefficient is therefore positive.

However, there is a second effect to consider with respect to this explanatory variable. Recall from Chapter 2 that it is expected that the domestic alliances in question are aimed at low elasticity consumers with high time/low price valuation. If this demand segment has stronger airport location preferences, then the absence of a competing airport may *prevent* the carriers to segment demand by elasticity. This then forms the basis of the expected sign of the $ARPT_r$ dummy variable to be negative.[61] (Expected Sign: Indeterminate).

3.3 Data: Source and Description

The Department of Transportation collects data from all large certified air carriers conducting scheduled passenger service. For each quarter, the raw data-base (the Ticket

[61] See Tirole (1994) on second-degree and third-degree price discrimination.

Dollar Value Origin and Destination, or 'O&D' data bank) contains domestic economy-class airfares and number of passengers on a route, identifies the carriers, the point of origin, intermediate airports, point of destination, distance and fare class. Since July 1987, the O&D has been based on a stratified, scientific sample of at least 1% of tickets in major domestic markets and 10% of tickets in all other domestic city-pair markets.

An important feature of the data is that post 1998, carriers were subject to new requirements of reporting both the operating and marketing carrier codes on each coupon of each record in their survey filings (as opposed to just the marketing carrier, which they had reported until the previous year). This feature allows the elimination of noise in the data due to any code-sharing. That is, credit is given to the carrier on which the passenger actually traveled instead of the carrier that marketed the flight.[62] Further details regarding data base construction form Appendix A.

Data is aggregated at the firm level within each route. Fare data represents the average coach class fare paid each way by (local and connecting) passengers for a round trip during a particular quarter, outbound from the base airport, such that at least one member of the alliance operated there.

3.4 Market Definition

The most relevant definition of the market for the purposes of this paper is the origin to destination air transportation market. Note first that this definition of a market is distinct from that of a route: a market represents the actual trip origin and destination, while a route represents the actual path flown by the passenger between his/her trip origin

[62] Pre-1998 data used in this paper has been adjusted to reflect this change in reporting practice.

and destination. Since passengers flying in the same market can fly a variety of different routes, travel from point A to point B is considered to be a different market than travel from point B to point A.

Second, a market is defined as travel between a unique airport pair, rather than a city pair. That is, travel from multiple airports in the same city is not aggregated. Reference will however be made to markets and routes interchangeably.

3.5 Treatment and Control Firms

The domestic operations of the 10 largest carriers in the domestic airline industry are considered. Just before the alliances were announced in 1998, these firms served over 87% of the domestic passenger traffic flying with major, low cost or regional carriers. For every alliance analyzed (the treatment group), the control includes the other eight largest carriers, that is, exclusive of only the two participating in the alliance. The big six carriers that formed the three major marketing alliances in 1998 were Delta-United, Northwest-Continental and US Airways-American. Non-participant rival carriers that we include in the control group are Alaska Air, America West, TWA and Southwest Airlines.

Other than the firms participating in the domestic alliances in question, the inclusion of only their four largest rival carriers was in part due to the understanding that these large and dominant firms represent a distinct group worthy of separation from their smaller rivals and from regional carriers. Evidence supporting this belief is common in the literature on the airline industry, for instance, Borenstein (1991) has shown that the advantages enjoyed by the largest firms in the industry flow not only due to cost and quality differences, but also their distinctly successful marketing strategies and reputation advantages.

This choice was further supported by the fact that the market shares of these four major rival carriers are already so low in many of the busiest markets that we are interested in, that they serve only as sporadic competitors to the big six carriers forming domestic alliances.

3.6 Airports Considered

The pool of airports considered is also a focused one. Specifically, alliance and rival firm operations on routes between each alliance hub airport and the busiest 45 airports of the country are considered.[63] These busiest airports of the country are ranked according to passenger enplanements in the 1999 ACI Monthly Traffic Statistics and are listed in Appendix B.

The airport selection criteria reflects the belief that these busy airports represent a distinct market.[64] For one, the competitive forces at play at these airports can be distinct from those at other smaller airports that a major carrier may service. Second, it is expected that the passenger traffic at these airports makes them the most relevant, not only for the benefits/burden from the realization of cost synergies/market power that may

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[63] The Federal Aviation Administration (FAA) defines a *large hub* as a geographical area in which its airports account for at least 1% of the total annual enplaned traffic. A carrier's network hub is the designated 'central' airport from where passengers are redistributed to their intended destinations.
[64] An argument supported in airline industry literature. For instance, see Borenstein (1988 and 1989) and Berry (1990).

result from an alliance agreement, but also with respect to the type of travelers most likely to be affected by the formation of domestic airline alliances.[65]

The sample of airports considered in this paper contains all those vital gateway cities on which carrier operations are constrained due to gate constraints or slot controls. Scarcity rents at these airports can be expected to affect fares there, especially for smaller carriers that are unable to expand in these markets,[66] as opposed to dominant carriers who tend to own their majority.[67] Airports with gate constraints or slot controls are listed in Appendix C and Appendix D lists the airports that have a second airport within the same metropolitan area.

3.7 Time Period Selection

In order to obtain a satisfactory answer to our primary hypothesis, an extended time period is selected. This is especially important in industries in which consumer loyalty plays an important role.[68]

Three specific periods for each alliance were earmarked: the quarter before the alliance was announced in the press, the quarter after alliance agreement but before its consummation, and the quarter nearly a year after the alliance had been operating.

The Northwest-Continental alliance was announced in the press on January 27th 1998 and started operations in December 1998. Therefore, the second quarter of 1998

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[65] This subset of markets is also of particular recent interest to agencies like the General Accounting Office. See for instance, U.S. General Accounting Office, GAO/RCED 90-102, 93-171, 97-4 and U.S. General Accounting Office, GAO/01-518T.

[66] See Dresner, Windle and Yao (2002) who find that these constraints have a significant impact on carrier yields.

[67] See U.S. General Accounting Office GAO/T-RCED-98-112.

[68] Focus on an extended time period allows a distinction between medium and long term goals of an alliance. Specifically, while the medium term goal of an alliance may be an increase in market share, its

was the period after alliance agreement, but before its consummation. The third quarter of 1999 was selected to capture firm behavior (nearly) a year after the alliance was operating.

The selection of quarters for the other two alliances required more judgement since both the Delta-United and the US Airways-American Airlines alliances were announced and consummated in two consecutive quarters. Specifically, the US Airways-American alliance was announced in the press early on April 5th 1998 and started operating in the middle of the third quarter of 1998, specifically in August 1998. Therefore the previous (that is, the second) quarter was selected as one that was 'after alliance agreement but before its consummation'. Similarly, the Delta-United alliance was announced on June 30th 1998 and began operation at the end of September 1998. Therefore, the third quarter of 1998 was selected as one that was 'after agreement but before consummation'. And for both, the third quarter of 1999 was selected to capture firm behavior a year after alliance operations. Table 3.1 shows these time periods for each alliance.

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long term goal can be focused on improving the bottom line, be it through reduced costs or through increased revenues.

Table 3.1: The Sample of Airline Alliances

	Enplaned Passengers [a]		Time Period [b]		
Alliance:	Airline 1	Airline 2	Before Negotiations	After Agreement	One Year After Alliance
DL-UA	27,549,985	21,941,274	Q2, 1998	Q3, 1998	Q3, 1999
NW-CO	13,679,584	560,776	Q4, 1997	Q2, 1998	Q3, 1999
US-AA	1,533,858	20,909,503	Q1, 1998	Q2, 1998	Q3, 1999

[a] Passenger data is for scheduled and unscheduled passengers, before or during preliminary alliance negotiations.
[b] Time period is shown as Quarter,Year. See Chapter 3, Section 3.7 for time period selection criteria.

3.7.1 The Timing of Fare Changes

Given that three quarters (t) are selected for each alliance, note that at t = 1 none of the firms participated in these alliances. By t = 2, the two firms had already announced the agreement and rival firms were excluded. Thus the *announcement effect* is defined as the fare change between t = 1 and t = 2. The change in fares between t = 2 and t = 3 is defined as the alliance *completion effect*: at t = 2, the two firms had not yet begun participation in the program, while at t = 3, the program was operating for about a year. The *full effect* considers fare changes between all three quarters that is, from before alliance announcement to a year into its full-fledged operations.[69]

In terms of our primary hypothesis of Section 2.2, consider that when two former competitors join operations or decision making at any level, potential efficiency improvements cannot be realized until the alliance is actually formed and operating.[70]

[69] This demarcation of time periods will be adopted throughout this paper and is similar to that in Kim and Singal (1993).
[70] There is a potential for improvements in efficiency after alliance formation, for instance by integrating redundancies betweeen the two firms and through economies of density. For instance, cost synergies can be realized due to better load factors, better coordination of ground crew, of flight arrival and departures and of gates and slots, through economies of scope and/or density, etc. See Bradley, Desai and Han (1983) who discuss synergistic gains and firm acquisition.

This points to the importance of the *completion effect* and the *full effect* for identification of greater cost synergies from alliance formation.[71]

However, the exercise of market power by a firm does not have to wait until the alliance is actually formed: fare changes can take place even on alliance announcement if the two carriers seek such gains. Consider the scenario in which two (formerly competing) management teams now have the opportunity to discuss and agree on mutually beneficial strategies. The importance of the *announcement effect*, the *completion effect* and the *full effect* is therefore established for identification of increased market power from alliance formation.

3.8 Evidence: Pooled OLS Estimates of the Impact of Alliance Formation on Fares

Independent and explanatory variable definitions are shown in Table 3.2. Table 3.3 shows pooled OLS estimation results with heteroscedasticity adjusted standard errors and White t-statistics.

Results in Table 3.3 show that the distance ($lDIST_r$) coefficient is unsurprisingly positive: longer trips have higher fares.[72] Since this and the dependent variable are in logs, it indicates that, for instance in terms of the full effect for the US Airways-American alliance network, that a one percent increase in distance raises average fares by about 25%. It is similarly positive and significant on other alliance networks and for all three time periods considered.[73]

[71] See Kim and Singal (1993) for a similar analysis of airline mergers.
[72] Distance is measured in statute miles/ 5,280 feet.
[73] The coefficient on Distance remained positive and significant in both linear and logarithmic forms. The latter is reported.

Table 3.2: Variable Definitions [a]

Variable	Definition
$lafare_{irt}$	Average one-way coach class fare for each round trip on carrier 'i', route 'r' and at time 't', taken in logs.
$ALLY_{irt}$	Alliance participation dummy variable indicating whether the firm 'i' on route 'r' was a member of a major domestic alliance at time 't'.
$lDIST_{r}$	The one-way non-stop and straight line distance ($DIST_r$) between endpoint airports of route 'r', taken in logs.
$Gate/\,Slot_{r}$	Dummy variable that indicates whether at least one endpoint of a route 'r' was gate controlled or slot constrained.[b]
$ARPT_{r}$	Dummy variable that indicates whether at least one endpoint airport of a route 'r' does not have second airport in the same metropolitan area.[c]
$Nfirms_{irt}$	The count of the number of rival firms of carrier 'i' operating on a route 'r' at time 't'. It is between 0 and 8 for alliance carriers and between 1 and 8 for the other major carriers.
D2/D3	Time dummy variables for the second/third quarter.

(a) See Appendix A for data description and data screening.
(b) See Appendix C for list of airports within the sample that are gate controlled or slot constrained.
(c) see Appendix D for list of airports within the sample that are *not* geographically 'isolated'.

The parameter estimates for the gate constraint/slot scarcity dummy variable ($Gate/Slot_r$) indicates that these time invariant constraints had a quantitatively important and statistically significant effect on fares of firms operating on all three alliance networks.

Table 3.3: Pooled OLS[a] Estimates of log ($fare_{irt}$).[b]

Dependent Variable: log ($fare_{irt}$) Network:		$ALLY_{irt}$	D2	D3	$lDIST_r$	$Gate/Slot_r$	$ARPT_r$	Constant	R^2	N
Full Effect	DL-UA	0.1348*	0.0107	-0.0474*	0.2696*	0.1053*	-0.0711*	3.3100	0.1400	18,657
		(0.0110)	(0.0110)	(0.0107)	(0.0084)	(0.0090)	(0.0128)	(0.0650)		
	NW-CO	0.0308*	0.0003	-0.0743*	0.2360*	0.0621*	-	3.6131	0.1051	12,852
		(0.0139)	(0.0131)	(0.0130)	(0.0102)	(0.0107)		(0.0769)		
	US-AA	0.1951*	-0.1132*	-0.1385*	0.2467*	0.0883*	0.0002	3.5856	0.1374	12,663
		(0.0142)	(0.0129)	(0.0130)	(0.0094)	(0.0103)	(0.0170)	(0.0706)		
Announcement Effect										
	DL-UA	0.1035**	-0.0059	-	-	0.1008*	-0.0697*	3.4879	0.1182	11,826
		(0.0149)	(0.0114)			(0.0111)	(0.0157)	(0.0765)		
	NW-CO	-0.0110	-0.0079	-	0.2345*	0.0768*	0.0022	3.6103	0.1044	8568
		(0.0199)	(0.0136)		(0.0125)	(0.0131)	(0.0197)	(0.0937)		
	US-AA	0.1651*	-0.1078*	-	0.2502*	0.0962*	0.0069	3.5509	0.1328	8442
		(0.0203)	(0.0133)		(0.0114)	(0.0128)	(0.0211)	(0.0705)		
Completion Effect										
	DL-UA	0.1625*	-	-0.0671*	0.2685*	0.0983*	-0.0625*	3.3288	0.1410	11,826
		(0.0162)		(0.0111)	(0.0101)	(0.0110)	(0.0152)	(0.0767)		
	NW-CO	0.0720*	-	-0.0878*	0.2277*	0.0544*	-0.0044	3.6827	0.0976	8568
		(0.0193)		(0.0137)	(0.0124)	(0.0131)	(0.0203)	(0.0933)		
	US-AA	0.1624*	-	-0785*	0.2456*	0.0881*	0.0006	3.5389	0.1280	8442
		(0.0138)		(0.0108)	(0.0094)	(0.0104)	(0.0171)	(0.0703)		

(a) With heteroskedasticity robust standard errors.

(b) See Table 3.2 for explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

Parameter estimates of Gate/Slot$_r$ were quantitatively similar in all three time periods. Its full effect parameter estimate ranged from 6% on the Northwest-Continental alliance network, to 10% on the Delta-United alliance network. With the average one way coach fare of $212.56 on the former network and $200.94 on the latter, the fare premium due to the scarcity of gates or slots was $13 and $20, respectively. These findings are roughly in conformity to previous research: Borenstein (1989) reported finding a range of premiums 1% to 7% at such airports in 1987 and Abramowitz and Brown (1993) found that carriers operating on slot controlled airports were able to extract a 4% fare premium in 1988.[74]

The statistically significant negative coefficient of ARPT on the Delta-United alliance network shows that this constraint served to depress fares there. Again, both its sign and magnitude were similar in all three time periods considered. Specifically, in the full effect period, fares were 7% lower on the Delta-United network when at least one endpoint airport was 'isolated'. Recall from section 3.2 that this finding is interpretable as that the absence of a competing airport in the same metropolitan area had served to prevent demand segmentation by elasticity, thereby keeping fares lower on such routes within the Delta-United network. On the networks of the other two alliances, the statistically insignificant coefficient on ARPT$_r$ shows that this constraint had no effect on fares there.

Parameter estimates of Nfirms$_{irt}$ remained consistently statistically insignificant, indicating that this proxy for the competitive state of a route had no impact on our

[74] Given that at least one member of the three major domestic alliances in question dominates ownership of gates at some of the country's busiest airports, this point estimate reflects for these carriers, the market power (as opposed to scarcity rent) associated with such ownership and control. See U.S. General Accounting Office GAO/T-RCED-98-112, for the percentage of slots that were owned by major carrier groups between 1986 and 1996.

dependent variable.[75] It was therefore excluded as an explanatory variable from this and subsequent regressions. Results also remained qualitatively unaltered due to its exclusion.

The parameter estimate of principal interest is the Alliance Participation dummy variable ($ALLY_{irt}$). Results in the first column of Table 3.3 show that it was positive and strong on all three networks. This result was evident even in the period corresponding to alliance announcement. For the full effect (defined earlier in Section 3.7.1), Table 3.3 shows that alliance participation was associated with fare increases ranging from 3% for the Northwest-Continental alliance to 19% for the US Airways-American alliance. These findings clearly show that that domestic alliance formation, resulting in pairings among the six most dominant carriers in the country, has lead to the realization of market power.

3.9 Mitigating a Potential Econometric Problem

The pooled OLS regressions in Table 3.3 may suffer from an econometric problem that will make previously discussed results unreliable. Specifically, pooled OLS estimates may be inconsistent due to the omitted variables problem since it ignores the impact of time constant unobserved effects on the dependent variable. For instance, there may be market specific and/or firm specific characteristics that affect fares (the dependent variable) and that have thus far been relegated to the idiosyncratic error term (U_{irt} in equation 3.3).

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[75] Recall that the sample of firms consists of the top ten major domestic carriers, two of which are linked through an alliance at any given time. The sample of routes consists of those between each alliance hub airport and the busiest 45 airports of the country, such that at least one alliance member firm operated there. Therefore Nfirms is bounded between zero and eight for alliance carriers and between one and eight for their rivals.

In term of the price equation, the basic model of unobserved heterogeneity in which such unobserved effects are explicitly included is:

$$\ln P_{irt} = X_{irt}\,\beta + U_{irt} + C_{ir} \tag{3.4}$$

where the dependent variable is the (log) average fare of firm 'i' on route 'r' at time 't'. X_{irt} is the vector of regressors, including a constant. Here, C_{ir} is the ***unobserved heterogeneity*** and its inclusion allows its correlation with alliance participation. This is especially important in the context of the alliance event since alliance participation was not randomly assigned, rather, member firms 'self-selected' into an alliance. At the firm level, it captures innate features such as managerial quality and the route level, for instance the 'mix' of passengers between leisure and business types. These features are unobserved characteristics that can be viewed as (roughly) constant over the time period of interest.

Within the methods available under the class of models of unobserved heterogeneity, the method of choice is the first difference transformation (FD). This is the panel data equivalent of the *difference in differences* approach and the general intuition behind it is to examine the impact of some 'treatment' on a firm and to compare its performance to a group of firms on which the treatment was not applied (the control).

The FD transformation lags the elements of the dependent and independent variables and subtracts them. If two quarters are considered, that is t = 2, then

$$\Delta \ln P_{irt} = \theta_2 + \Delta X_{irt}\,\beta + \Delta U_{irt} \tag{3.5}$$

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where $\Delta \ln P_{irt} = \ln P_{irt} - \ln P_{ir,t-1}$ and θ_2 is the second period intercept.

After the FD transformation, the first time period considered for each cross section is lost since there is no first difference for these observations. Similarly, any time invariant element of the X_{irt} vector, as well as time invariant (unobservable) elements of a firm's managerial quality (captured by C_{ir} in equation 3.4), will drop out due to the application of the FD transformation. The adoption of the FD method thus also allows an abstraction from the influence of hub specific effects on the dependent variable.[76] To the extent that the prime interest is in time varying explanatory variables, this feature does not represent a significant limitation.

After the FD transformation, the parameter estimate of the time dummy variable measures the *growth* in average fares for firms that are in the control group and over the period, due to aggregate factors in the economy, ceteris paribus. If β_2 is the coefficient on the Alliance Participation dummy variable ($ALLY_{irt}$) at t = 2, then $\beta_2 + \theta_2$ measures the *growth* in average fares for the treatment firms during this period.

The parameter estimate of the Alliance Participation dummy variable ($ALLY_{irt}$) shows the difference in the *growth* of average fares between the treatment and control firms (or the growth of the price gap), ceteris paribus. Thus again, the sign of the coefficient on the Alliance Participation dummy variable ($ALLY_{irt}$) provides the answer to the primary hypothesis of improved efficiency versus increased market power resulting from the formation of a major domestic alliance. If greater efficiency/cost synergies are

[76] The latter refers to the fare premiums carriers may charge on travel to and from its hub airports, relative to those on the rest of its route system. Borenstein (1989) documents such a hub premium at dominated airports. See also Lee and Prado (2003) who examine the effect of the mix of passengers by fare class on reported hub premiums. They find that while a hub premium does exist, much of it is explainable by passenger mix. Specifically, they find that failure to control for passenger type, inflates the average hub premium by 11.9% to 20.8% for restricted coach passengers. They also find that the hub airports with the

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realized from alliance participation, then lower costs (B^c_{irt} in equation 2.4) should act to lower the growth in the price gap between alliance and rival firms ($ALLY_{irt} < 0$). On the other hand, if the market power effect dominates then the growth in the price gap between alliance and rival firms will be positive ($ALLY_{irt} > 0$).

Thus while this method is comparable to that of Bamberger, Carlton and Neumann (2001) reviewed earlier in Chapter 2 (Section 2.3.5) in that improved efficiency and increased market power have opposing effects on fares, there are important differences in the approach. First, the nature of the alliances they examine is different in that code-sharing alliances were not system-wide arrangements. Thus their sample and control could be selected on the basis of specific routes on which the alliance did and did not operate, rather than at the firm level.

Second, they considered a large pool of firms, consisting not only of major carriers but also of the smaller commuter carriers operating on the sample and control routes of interest.[77] In fact, not only is information from smaller (and arguably distinctly different) firms pooled with that of the larger carriers, a very large route network of these carriers was considered. And third, they examine the impact of these code-sharing alliances from before the alliances began to a year after they had been operating, while in Section 3.7, analysis over a longer time period is defended.

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largest premiums are smaller cities that serve thinner routes and that use aircraft that are more costly to operate. Also see Liu (2003).

[77] Commuter carriers are defined as those that operate predominantly propeller-driven aircraft in scheduled passenger service and in predominantly short haul service.

3.10 Evidence: First Difference Estimates of the Impact of Alliance Formation on Fares

Table 3.4 reports the FD estimates of equation 3.4, after time invariant explanatory variables were dropped.[78] Parameter estimates in this table reveal that our results are quite robust to the method of estimation. For all three alliances, the parameter estimates of the explanatory variable of prime interest (that is, $ALLY_{irt}$) changed slightly in magnitude between pooled OLS and FD, showing that controlling for unobserved route and firm effects was somewhat important. However, it was again positive and strong in magnitude. While standard errors were higher after first differencing, it maintained statistically significance at the 1% level.

Comparing the parameter estimates of the Alliance Participation dummy variable ($ALLY_{irt}$) from pooled OLS estimation (Table 3.3) with those from first differencing (Table 3.4), for instance for the full effect for the US Airways-American alliance, shows that the fare impact ($lfare_{irt}$) from participation in this alliance varied from 19% to 22%. For Delta-United, the association between the dependent variable and the Alliance Participation variable was lower after first differencing, varying from 13% from pooled OLS estimation to 11% after first differencing. However, the strength of the evidence remained largely unaltered: the consistently positive and statistically significant parameter estimate of the Alliance Participation dummy ($ALLY_{irt}$) provides strong evidence that alliance participation is responsible for generating fare premiums for the participant carriers.[79]

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[78] Results are reported with heteroscedasticity adjusted standard errors and White t-statistics.

[79] To check the sensitivity of our results to our method of selection of the control firms we also estimated the impact of alliance participation, taking the members of the *other* two major domestic alliances jointly *if* warranted at the time period under consideration. Results showed robustness to this alternative construction and only one set of results is reported here: with the other four alliance carriers taken as separate firms at each time period.

Table 3.4: First Difference[a] Estimates of log (fare $_{irt}$).[b]

Dependent Variable: log (fare $_{irt}$)	Network:	ALLY $_{irt}$	D2	D3	Constant	R^2	N
Full Effect	DL-UA	0.1115*	0.0673*	0.0255**	0.0280	0.0086	18,657
		(0.0145)	(0.0173)	(0.0177)	(0.0121)		
	NW-CO	0.0472*	-0.0114	-0.0005	-0.0366	0.0015	12,852
		(0.0185)	(0.0226)	(0.0233)	(0.0149)		
	US-AA	0.2241*	0.0469**	0.0578*	-0.1096	0.0233	12,663
		(0.0226)	(0.0235)	(0.0245)	(0.0158)		
Announcement Effect							
	DL-UA	0.1488*	0.0813*	-	0.0212	0.0117	11,826
		(0.0203)	(0.0176)		(0.0121)		
	NW-CO	0.0215	-0.0301***	-	0.0500	0.0011	8568
		(0.0252)	(0.0235)		(0.0153)		
	US-AA	0.2218*	0.0458**	-	0.1092	0.0177	8442
		(0.0309)	(0.0249)		(0.0158)		
Completion Effect							
	DL-UA	0.0751*	-	-0.0247***	0.0709	0.0038	11,826
		(0.0204)		(0.0183)	(0.0121)		
	NW-CO	0.0735*	-	0.0298	0.0114	0.0024	8568
		(0.0271)		(0.0247)	(0.0160)		
	US-AA	0.2089*	-	0.0321***	-0.0885*	0.0222	8442
		(0.0210)		(0.0201)	(0.0117)		

(a) With heteroskedasticity robust standard errors.

(b) See Table 3.2 for dependent and explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

While the Northwest-Continental alliance was the first to be publicly announced, the US Airways-American alliance was the first to begin operations. The first column of Table 3.4 shows that for each time period examined, the growth in the price gap between the US Airways-American alliance and its major rivals was the greatest among the alliances examined. For this, as for the other two major domestic alliances, results indicate the absence of an 'umbrella effect' to benefit rival carriers.[80]

Table 3.4 also provides evidence that the realization of market power took place even before these alliances were up and running: in the alliance announcement period, the Alliance Participation dummy variable was positive and statistically significant for all three major domestic alliances. From the first column of Table 3.4 it is seen that immediately after alliance announcement, (average) fare growth of the Delta-United alliance was 15% more than that of its largest rival carriers serving the same markets.[81] This timing of growth in the price gap shows that increased market power was realizable even at announcement of alliance participation.[82] This could have been made possible either since alliance announcement allowed the conversion of a former competitor to an ally, *or* due to the advantages accruing to a firm now seeming to operate at a larger size.

After alliance completion, average fares of the Delta-United alliance grew at about 5%,[83] while the (average) fares of its rivals fell 2% (due to aggregate economy wide factors). Thus the growth in the price gap between this alliance and its rival firms

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[80] Borenstein (1989) found that rival carriers did not benefit from higher markups of the dominant carriers, while Kim and Singal (1993) had found that rival fare movements closely followed those of the merging carriers.
[81] Recall that while the Delta-United alliance was the last to be announced, it was quick to begin operations.
[82] Similar results were found by Borenstein (1990) and by Kim and Singal (1993). The former found that when Northwest and Republic Airlines merged in 1986, its fares were higher in routes to and from its Minneapolis hub even before the merger. The latter found that large increases in airfares in the announcement period of firms that were merging but were not financially distressed.
[83] This is calculated as 0.0751 -0.0247 for the Delta-United alliance in the alliance completion period.

had increased 7% between the fourth quarter of 1988 and the third quarter of 1999 and this is noted in Table 3.4 as the parameter estimate of the Alliance Participation dummy ($ALLY_{irt}$) in the alliance completion period.

3.11 Hub-Specific Evidence: First Difference Estimates of the Impact of Alliance Formation on Fares

Table 3.5 reports the hub-specific first difference estimates for the fare impact from alliance participation. Pooled OLS hub-specific results are shown in Appendix E for comparative purposes. Again, parameter estimates from the adoption of these alternative methods of estimation consistently show robustness to this choice.

First, note the growth in the price gap between alliance and rival carriers at Chicago O'Hare (ORD) and at Dallas Fort Worth (DFW). These two airports are 'double-hubs' in that they are hub airports of both the Delta-United alliance[84] and the US Airways-American alliance.[85]

The growth in the price gap at Chicago O'Hare (ORD) due to the formation of these two alliances was not statistically significant. At Dallas Fort Worth (DFW), while the growth in the price gap was again not statistically significant due to the Delta-United alliance at any of the three time periods, results for the US Airways-American alliance were dramatically different there. In fact, parameter estimates of the US Airways-American Alliance Participation dummy variable ($ALLY_{irt}$) were stronger there than at

[84] Six of the nine Delta-United alliance hubs are considered concentrated. See U.S. General Accounting Office, GAO/RCED-90-147 and U.S. General Accounting Office, GAO/RCED- 90-102.
[85] In 1996, American and United owned 87% of the landing slots at Chicago O'Hare.

Table 3.5: Hub Specific First Difference[a] Estimates of log (fare $_{irt}$).[b]

Dependent Variable: log (fare $_{irt}$)	ALLY $_{irt}$	D2	D3	Constant	R^2	N
A.Delta-United:						
Full Effect						
Atlanta (ATL)	0.0770	0.7524*	0.7027*	-0.6717	0.0485	2106
	(0.0806)	(0.3042)	(0.3076)	(0.3050)		
Cincinnati (CVG)	0.0809	0.7629	0.8267	-0.8512	0.0572	2106
	(0.0804)	(0.3181)	(0.3224)	(0.3093)		
Denver (DEN)	0.0822**	-0.5407*	-0.5224*	0.6065	0.0402	2106
	(0.0477)	(0.2434)	(0.2436)	(0.2406)		
Dallas (DFW)	-0.0068	0.2636	0.2216	-0.1802	0.0089	2079
	(0.0429)	(0.2393)	(0.2413)	(0.2358)		
Dulles (IAD)	0.1466**	0.1772	0.1983	-0.0740	0.0073	1998
	(0.0802)	(0.2228)	(0.2262)	(0.2203)		
Los Angeles (LAX)	0.1116*	0.0293	0.0138	0.0349	0.0056	2106
	(0.0277)	(0.1745)	(0.1740)	(0.1717)		
Chicago (ORD)	0.0673	0.3219*	0.3257*	-0.1749	0.0071	2052
	(0.1091)	(0.1022)	(0.1041)	(0.0872)		
San Francisco (SFO)	0.1543**	0.1393*	0.1446*	-0.0827	0.0035	1998
	(0.0992)	(0.0987)	(0.0956)	(0.0874)		
Salt Lake City (SLC)	0.3109*	0.3335*	0.1902*	-0.1280	0.0041	2106
	(0.1051)	(0.0795)	(0.0807)	(0.0552)		
Announcement Effect						
Atlanta (ATL)	0.1190	0.2514*	-	-0.1597	0.0096	1404
	(0.1226)	(0.1008)		(0.0878)		
Cincinnati (CVG)	0.2147*	0.3168	-	-0.3569	0.0095	1404
	(0.0993)	(0.1510)		(0.1248)		

Table 3.5 (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	Constant	R^2	N
Denver (DEN)	0.0781***	-0.0809	-	0.1462	0.0033	1404
	(0.0615)	(0.0756)		(0.0639)		
Dallas (DFW)	0.0253	0.0859	-	0.0078	0.0016	1386
	(0.0548)	(0.0802)		(0.0691)		
Dulles (IAD)	0.2260*	0.1259***	-	-0.0026	0.0058	1332
	(0.1241)	(0.0971)		(0.0815)		
Los Angeles (LAX)	0.1744*	0.0332	-	0.0356	0.0062	1404
	(0.0426)	(0.0536)		(0.0450)		
Chicago (ORD)	0.1146	0.2612	-	-0.0999	0.0029	1368
	(0.1681)	(0.0919)		(0.0640)		
San Francisco (SFO)	0.1878***	0.1262	-	-0.0650	0.0026	1332
	(0.1402)	(0.0832)		(0.0680)		
Salt Lake City (SLC)	0.3209*	0.3249	-	-0.1186	0.0035	1404
	(0.1281)	(0.0772)		(0.0515)		
Completion Effect						
Atlanta (ATL)	0.1508***	-	0.1001	-0.1089	0.0038	1404
	(0.1247)		(0.0983)	(0.0823)		
Cincinnati (CVG)	-0.0498	-	0.3244	-0.3986	0.0145	1404
	(0.1238)		(0.1683)	(0.1292)		
Denver (DEN)	0.0822	-	-0.0914	0.1761	0.0041	1404
	(0.0720)		(0.0754)	(0.0627)		
Dallas (DFW)	-0.0637	-	0.0075	0.0135	0.0086	1386
	(0.0663)		(0.0877)	(0.0680)		
Dulles (IAD)	0.2010**	-	0.1213	0.0177	0.0048	1332
	(0.1386)		(0.1057)	(0.0795)		

Table 3.5 (cont'd).

Table 3.5 (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	Constant	R^2	N
Los Angeles (LAX)	0.0515***	-	-0.0015	0.0448	0.0006	1404
	(0.0375)		(0.0508)	(0.0441)		
Chicago (ORD)	0.1177	-	0.2563*	-0.0904	0.0028	1368
	(0.1585)		(0.0948)	(0.0657)		
San Francisco (SFO)	0.1206	-	0.1242**	-0.0680	0.0017	1332
	(0.1351)		(0.0813)	(0.0701)		
Salt Lake City (SLC)	0.3048*	-	0.1704	-0.1090	0.0020	1404
	(0.1356)		(0.0789)	(0.0514)		
B. Northwest-Continental:						
Full Effect						
Cleveland (CLE)	0.0767**	0.0304	0.0232	0.0171	0.0050	2133
	(0.0313)	(0.0446)	(0.0434)	(0.0284)		
Detroit (DTW)	-0.0058	0.0010	-0.0306	-0.0090	0.0007	2160
	(0.0441)	(0.0494)	(0.0530)	(0.0312)		
Houston (IAH)	-0.2157	-0.1482**	-0.1348**	0.1386	0.0216	2160
	(0.0740)	(0.0678)	(0.0754)	(0.0455)		
Memphis (MEM)	0.0511	-0.0408	-0.0046	0.0339	0.0027	2133
	(0.0510)	(0.0721)	(0.0680)	(0.0466)		
Minneapolis (MSP)	0.2215*	0.0098	0.1007**	0.0055	0.0373	2187
	(0.0381)	(0.0502)	(0.0513)	(0.0351)		
Newark (EWR)	-0.1379**	-0.0977**	-0.1293	0.0613	0.0093	2079
	(0.0595)	(0.0594)	(0.0651)	(0.0387)		
Announcement Effect						
Cleveland (CLE)	0.0453	-0.0049	-	0.0502	0.0012	1422
	(0.0387)	(0.0458)		(0.0300)		

Table 3.5 (

Table 3.5 (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	Constant	R^2	N
Detroit (DTW)	-0.0850***	-0.0203	-	-0.0090	0.0026	1440
	(0.0577)	(0.0526)		(0.0312)		
Houston (IAH)	-0.3167*	-0.2015*	-	0.1481	0.0320	1422
	(0.1022)	(0.0689)		(0.0463)		
Memphis (MEM)	0.1481**	0.0022		0.0326	0.0107	1458
	(0.0781)	(0.0817)	-	(0.0473)		
Minneapolis (MSP)	0.1815*	-0.0137	-	0.0278	0.0158	1386
	(0.0505)	(0.0514)		(0.0367)		
Newark (EWR)	-0.0948	-0.0944***	-	0.0698	0.0050	
	(0.0850)	(0.0630)		(0.0392)		
Completion Effect						
Cleveland (CLE)	0.1082**	-	0.0192	0.0237	0.0065	1422
	(0.0493)		(0.0472)	(0.0342)		
Detroit (DTW)	0.0807	-	-0.0086	-0.0064	0.0028	1440
	(0.0666)		(0.0587)	(0.0328)		
Houston (IAH)	-0.1141	-	-0.0517	0.0908	0.0053	1440
	(0.1065)		(0.0834)	(0.0491)		
Memphis (MEM)	-0.0287	-	0.0314	-0.0256	0.0013	1422
	(0.0667)		(0.0701)	(0.0432)		
Minneapolis (MSP)	0.2630*	-	0.1462*	-0.0385	0.0463	1458
	(0.0570)		(0.0530)	(0.0377)		
Newark (EWR)	-0.1826**	-	-0.1309**	0.0518	0.0114	1386
	(0.0831)		(0.0699)	(0.0388)		

Table 3.5 (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	Constant	R^2	N
C. US Airways-American:						
Full Effect						
Charlotte (CLT)	0.2029*	0.0464	0.0109	-0.1321	0.0219	2533
	(0.0625)	(0.0843)	(0.0793)	(0.0577)		
Dallas (DFW)	0.3250*	0.0406	0.0686	-0.0919	0.0432	2506
	(0.0514)	(0.0511)	(0.0560)	(0.0384)		
Miami (MIA)	0.1283*	-0.0167	0.0381	-0.0847	0.0095	2425
	(0.0467)	(0.0550)	(0.0583)	(0.0368)		
Chicago (ORD)	0.1110	-0.2234	0.0102	-0.1363	0.0548	295
	(0.2196)	(0.1676)	(0.3769)	(0.1445)		
Philadelphia (PHL)	0.1138**	0.0327	0.0223	-0.1223	0.0063	2452
	(0.0487)	(0.0535)	(0.0536)	(0.0324)		
Pittsburgh (PIT)	0.1968*	0.0788***	0.1351**	-0.1550	0.0266	2452
	(0.0574)	(0.0588)	(0.0623)	(0.0379)		
Announcement Effect						
Charlotte (CLT)	0.2857*	0.0838	-	-0.1390	0.0271	1692
	(0.0904)	(0.0922)		(0.0578)		
Dallas (DFW)	0.2796*	0.0207	-	-0.0842	0.0248	1674
	(0.0664)	(0.0531)		(0.0390)		
Miami (MIA)	0.1274**	-0.0222	-	-0.0795	0.0086	1620
	(0.0626)	(0.0590)		(0.0371)		
Chicago (ORD)	0.0809	-0.2334***	-	-0.1363	0.2387	198
	(0.1282)	(0.1585)		(0.1493)		
Philadelphia (PHL)	0.1046**	0.0300	-	-0.1223	0.0042	1638
	(0.0711)	(0.0576)		(0.0324)		

Table 3.5 (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	Constant	R^2	N
Pittsburgh (PIT)	0.2467*	0.0990**	-	-0.1550	0.0309	1638
	(0.0760)	(0.0627)		(0.0379)		
Completion Effect						
Charlotte (CLT)	0.1228**	-	0.0035	-0.1561	0.0072	1692
	(0.0860)		(0.0803)	(0.0508)		
Dallas (DFW)	0.3703*	-	0.1266**	-0.1386	0.0474	1674
	(0.0773)		(0.0550)	(0.0312)		
Miami (MIA)	0.1292**	-	0.0934	-0.1398	0.0081	1620
	(0.0694)		(0.0623)	(0.0438)		
Chicago (ORD)	0.1378	-	0.2774	-0.3967	0.0481	198
	(0.4029)		(0.4013)	(0.0543)		
Philadelphia (PHL)	0.1231**	-	0.0250	-0.1224	0.0051	1638
	(0.0667)		(0.0607)	(0.0373)		
Pittsburgh (PIT)	0.1485**	-	0.1173**	-0.1559	0.0127	1638
	(0.0857)		(0.0684)	(0.0388)		

(a) With heteroskedasticity robust standard errors.
(b) See Table 3.2 for explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.
*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

any other hub airport.[86] For instance, in the full effect period, the parameter estimate of the Alliance Participation dummy variable shows that this alliance was associated with a 32% growth in the price gap between US Airways-American and its major rival firms on some of the busiest routes in its network.

At the Northwest-Continental Minneapolis (MSP) hub, the growth in the price gap due to the formation of this alliance was a strong 22%, indicating the dominance of the increased market power effect there from the formation of this alliance.[87] On routes to and from Cleveland (CLE), formation of the Northwest-Continental alliance had resulted in a 7% growth in the price gap.[88] The only hub airport at which there was evidence of the realization of improved efficiency/cost synergy from alliance formation was Newark (EWR).[89] There, formation of the Northwest-Continental alliance had resulted in a 13% drop in the price gap between this alliance and its major rival carriers serving the same markets.

Thus overall, evidence in Table 3.5 shows that domestic alliance formation had a positive and statistically significant fare impact at a majority of the alliance hub airports, providing strong and clear evidence of the realization of increased market power from these three alliances.[90] The only exception was at Newark (EWR), a Northwest-

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[86] Except in the announcement period, when the US Airways-American Alliance Participation dummy variable was slightly stronger at Charlotte than at Dallas Fort Worth.

[87] Borenstein (1990) reported that by 1987, the merger between Northwest and Republic had resulted in relative fares at Minneapolis to be 38% higher than industry average fares.

[88] While low cost Southwest Airlines did create competitive pressures for the Northwest-Continental alliance, it was only on a handful of markets with Cleveland or Detroit as one endpoint. See Boguslaski, Ito and Lee (2002) for a detailed examination of the entry strategy of Southwest, along with predictions regarding its future entry. For more evidence on the competitive effects from low cost/low-fare competitors see U.S. General Accounting Office, GAO/01-518T.

[89] Pooled OLS results in Appendix E identify Houston (IAH) as the Northwest-Continental hub at which improved efficiency was realized due to alliance formation. After the FD transformation though, the Alliance Participation dummy variable, while still negative, was not statistically significant there.

[90] Five of the six hub airports of the US Airways-American alliance were considered 'concentrated' by the U.S. General Accounting Office. See U.S. General Accounting Office, GAO/RCED-90-147 and U.S.

Continental hub where alliance participation was associated with the realization of improved efficiency/cost synergies.[91]

3.12 Synopsis and Conclusion

The recent trend between the country's most dominant carriers of forming alliances on domestic route networks seems to have replaced the mega-mergers that took place immediately after deregulation. In this chapter we sought to answer the question of whether the effect of each of these alliances been the realization of some efficiencies or that of increased market power.

While pooled OLS estimation results provided strong and consistent evidence of the overall dominance of increased market power from the formation of each of the three major domestic alliances, the adoption of the first difference method provided results that were largely quantitatively similar. That is, controlling for unobserved firm and route heterogeneity had only slightly improved our insight into the relationship between alliance formation and the dependent variable.

First difference estimation showed that on the busiest routes served by each of the three major domestic alliances, alliance participation had a quantitatively important and statistically significant impact on the (positive) growth in the price gap. These results not only clearly demonstrate the dominance of increased market power from alliance participation, but also that firms that had remained 'outside' such agreements had been

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General Accounting Office, GAO/RCED- 90-102. See previous footnote for criteria employed for defining an airport as 'concentrated'.

[91] Other than Memphis and Cleveland, all Northwest-Continental hub airports were already 'concentrated' even before the alliance was formed. The U.S. General Accounting Office defines a concentrated airport as one where one airline handled at least 60% of the enplaned passengers, or two carriers carried 85% of the

unable enjoy a fare 'umbrella'. The increased market power enjoyed by domestic alliance forming firms could have been made possible either since this event allowed the conversion of a former competitor to an ally (that is, there was a reduction in the number of competitors by one), *or* due to the advantages accruing to the firm now operating at a larger size.

The next obvious question is whether the noted trajectory in the growth of alliance fares can be supported by any quality improvements taking place due to alliance formation. Unfortunately we are unable to proceed in this direction, first since the O&D data-base of the Department of Transportation does not provide this information on a route specific basis. Second, while alternative sources of carrier service-data exist, for instance the Bureau of Transportation Statistic's *Air Carrier Statistics (Form 41 Traffic)-T-100 Domestic Segment* data-base, this data is incompatible with that of the O&D.[92] These two constraints made this exercise beyond the scope of this paper and it proceeds with an examination of the competitive impact of domestic alliance formation, armed with an estimation method that allows improved control of unobservable influences on the dependent variable.[93]

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total enplaned passengers. See U.S. General Accounting Office, GAO/RCED-90-147 and U.S. General Accounting Office, GAO/RCED- 90-102.

[92] This data base and the O&D data base are constructed under different criteria. Specifically, the former provides information on the basis of non-stop flights while the later, on direct flights that may have more than one stop.

[93] The relationship between changes in quality and fare changes can also be difficult to interpret. For instance, one common measure of quality in the airline industry is load factor, defined as the percentage of seats filled. While on the one hand higher load factors can be expected to reduce fares due to lower costs and may even signal lower quality due to greater crowding on the plane, on the other, high load factors may be achieved during periods of high demand when fares should be higher. Similar ambiguity exists with a measure of quality like circuity, defined as the ratio of the actual route distance to the distance flown on the route. Thus some common measures of quality in this industry present us with the possibility of controversial and ambiguous interpretations due to their multi-dimensional impact on changes in fares.

Chapter 4. Alliance Formation and Airport Dominance

In this chapter, the query of the competitive impact of domestic airline formation is taken further. Specifically, this chapter aims to quantifying the impact of alliance formation on airport dominance.

4.1 The Fare Impact of Airport Dominance

The strength and direction of the relationship between airport dominance and fares has been well established in previous research on the airline industry. For instance Evans and Kessides (1993) found that control of airport facilities confers the carrier significant power over fares. Borenstein (1989) found that both route and airport level dominance determine the degree of market power exercised by a carrier.[94]

This direct relationship between fares and airport dominance was reconfirmed on our sample of routes and for the time periods corresponding to alliance formation: when a proxy for airport dominance[95] was included as an explanatory variable in the price equation 3.3, the magnitude of the Alliance Participation dummy variable ($ALLY_{irt}$, defined earlier in Table 3.2) decreased. Specifically, the inclusion of a proxy for airport dominance reduced the quantitative impact of the Delta-United Alliance Participation dummy variable from 11% (noted earlier in Table 3.4) to 6%. The Northwest-Continental Alliance Participation dummy variable fell from 5% (in Table 3.4) to negative 4%, and the US Airways-American Alliance Participation dummy variable fell from 22% (in Table 3.4) to 3%. In all three cases however, it maintained statistical

[94] These papers were reviewed earlier in Chapter 2, Section 2.3.2.

significance at standard levels of significance. The dramatic decrease in the Alliance Participation dummy variable ($ALLY_{irt}$) when a proxy for airport dominance was included in the price equation shows that the dominant market power effect ($ALLY_{irt} > 0$) found in the previous chapter, was power conveyed through the control of airport facilities.[96]

Given this, it is useful to quantify the relationship between each alliance event and the change in this (now familiar) source of market power. This is the basis of the investigation in this chapter and is undertaken to provide greater clarity to the increased market power result of Chapter 3.

Before proceeding, note that on the one hand, the direct relationship between a carrier's fares and its airport dominance may be explainable by the 'natural' benefits that the dominant carrier enjoys due to its reputation. First, for instance, it may be seen to offer better service, more frequent flights etc.[97] This advantage is enhanced by the Frequent Flyer Program since travelers prefer to enroll in a program that will provide the most destination choices at the time of reward redemption, along with a greater possibility of having successfully accumulated the required mileage.[98]

On the other hand, airport dominance can create entry barriers: the dominant carrier may enjoy bargaining power over airport authorities if it is an important source of revenue for the airport and this may play a role in gate and slot allocation there. Similarly, if the dominant carrier already owns the majority of gates/slots at an airport, it

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[95] The proxy for airport dominance will be defined in Table 4.1.

[96] In Chapter 3, the potential problem of the inconsistency of parameter estimates due to the omitted variables problem is reduced by the adoption of the first difference estimation method.

[97] Nako (1992) found that for business travelers, flight frequency had the largest impact on firm choice. Toh and Hu (1988) report that these travelers value convenient schedules.

can refuse to sell or lease them to rivals wishing to expand and/or entrants wishing to enter.[99]

4.2 Explanatory Variables and Expected Signs

The (log of) Airport Market Share (AM_{irt}) is taken as the dependent variable and it is defined as the carrier's average share of traffic[100] on *all* markets it serves from the two endpoint airports of the route.[101] Captured by A^d_{irt} in the structural equation 2.4, it proxies the carrier's airport-level dominance.

The vector of explanatory variables includes a constant plus:

1. The Alliance Participation Dummy variable, that indicates whether the firm is an alliance member ($ALLY_{irt}$). It is defined as one when the firm is a partner of the major domestic alliance in question, and zero otherwise. (Expected Sign: Positive).

2. T-1 Time Dummy variables, to control for the effects of macroeconomic factors on the dependent variable.

[98] The impact of the non-linear structure of Travel Agent Commission Override programs (TACO's) is also important as it favors the dominant firm. Similarly, ownership of a Computer Reservation System (CRS) furthers the carrier's airport dominance advantage.
[99] See U.S. General Accounting Office (GAO/RCED-90-147) on entry deterrence by larger carriers due to their ownership of gates and slots at important airports.
[100] Traffic is defined as the sum of *all* enplaned passengers, local and connecting.
[101] This definition of airport market share is similar to that of Borenstein (1989). Borenstein (1991) and Evans and Kessides (1993 and 1994) use a slightly different construction.

3. Route Market Share (MS_{irt}), defined as the percentage of all coach passengers traveling on carrier 'i', route 'r', at time 't'.[102] Given that the sample of firms is limited to the ten largest domestic carriers (as justified earlier in Chapter 3, Section 3.4), Route Market Share (MS_{irt}) is calculated as if these 10 carriers were the only contenders for passengers on the sample of routes.

Note that to correctly assess the movements in the market share of the alliance firm, alliance total post-alliance market share should be compared to their total pre-alliance market share. This is since once two firms have entered into an alliance their joint market share will necessarily be greater than it was of the individual pre-alliance firms. For carriers remaining 'outside' the agreement, it is calculated as their simple average market share (Expected Sign: Positive).

4. An explanatory variable to control for the impact of gate or slot unavailability ($Gate/Slot_r$).

If carriers are constrained in their ability to expand or enter an airport, the changes in their airport dominance there will be lower. For incumbent carriers, this can be due to genuine limits on the number of gates or slots available for expansion, while for new entrants, this could be a constraint if the incumbent carriers refuse to lease or sell slots/gates in an attempt to limit rival firm expansion and entry at these airports. Both these conditions create an expectation for a negative parameter estimate for this variable. (Expected Sign: Negative).

[102] See for instance, Evans and Kessides (1993).

5. An explanatory variable to control for the geographical 'isolation' of at least one endpoint airport (*$ARPT_r$*). It is expected that such 'singular' airports will be associated with lower airport dominance changes as carriers have less 'space' to expand: rival carries and entrants interested in serving that city will all serve out of the same airport. Also, such airports can have higher Passenger Facility Charges (PFCs) and/or higher delay costs due to congestion problems. These conditions create an expectation for a negative parameter estimate for this variable

Conversely, the lower expected competitive pressures due to the absence of such a second facility could be associated with higher airport dominance. (Expected Sign: Indeterminate).

4.3 Method of Inquiry

As in the previous chapter, three specific quarters are selected: the quarter before the alliance was announced in the press, the quarter after alliance agreement but before its consummation, and the quarter nearly a year after the alliance had been operating. For each major domestic alliance, Table 3.1 showed the actual quarter selected.

The timing of the change in airport dominance will be presented as the full, announcement and completion effects. The *announcement effect* captures the impact of alliance formation on airport dominance between the first two quarters selected, that is, between t = 1 and t = 2. Similarly, the *completion effect* captures the change in airport dominance afforded by alliance participation between t = 2 and t = 3. The *full effect* considers the change in airport dominance due to the alliance in all three quarters, that is from before alliance announcement to a year into its full-fledged operations.

Dependent and independent variables used in this chapter are defined in Table 4.1 and variable summary statistics form Table 4.2.

Table 4.1: Variable Definitions [a]

Variable	Definition
AM_{irt}	Carrier 'i''s average total market share from the two endpoint airports of route 'r' at time 't', taken in logs.
$ALLY_{irt}$	Alliance participation dummy variable indicating whether the firm 'i' is a member of a major domestic alliance at time 't'.
MS_{irt}	Total route market share of alliance member 'i' on route 'r' at time 't'. Average route market share for rival carriers.
Gate/ $Slot_r$	Dummy variable that indicates whether at least one endpoint of a route 'r' is gate or slot constrained.[b]
$ARPT_r$	Dummy variable that indicates whether at least one endpoint airport of a route 'r' does *not* have second airport in the same metropolitan area.[c]
D2/D3	Time dummy variables for the second/third quarter.
$lagMS_{irt}$	The two period lagged MS_{irt} for carrier 'i' on route 'r' at time 't'.
$RANK_{irt}$	The rank of the MS_{irt} of carrier 'i' on route 'r' at time 't', calculated in descending order.

(a) See Appendix A for data description and screening.

(b) See Appendix C for list of airports within the sample that are gate or slot constrained.

(c) see Appendix D for list of airports within the sample that are not geographically 'isolated'.

Table 4.2: Variable Descriptive Statistics [a]

Variable	Network	Mean	s.e.	Min.	Max.
Full Effect					
$Fare_{irt}$	DL-UA	200.94	122.23	18	1757
	NW-CO	212.56	125.96	19	2591
	US-AA	217.68	118.77	15	1797
AM_{irt} (%)	DL-UA	12.29	14.88	0.1	88.6
	NW-CO	13.52	13.53	0.2	88.6
	US-AA	14.35	15.91	0.2	96.7
MS_{irt} (%)	DL-UA	19.09	27.11	0	100
	NW-CO	19.10	27.53	0.1	100
	US-AA	19.52	27.25	0.1	100
$DIST_r$	DL-UA	1177.47	673.20	30	2704
	NW-CO	989.12	587.84	17	2565
	US-AA	1021.65	655.15	67	2724
$lagMS_{irt}$ (%)	DL-UA	19.09	27.11	0.1	100
	NW-CO	12.85	24.30	0	100
	US-AA	12.27	22.99	0	100
Announcement Effect					
$Fare_{irt}$	DL-UA	202.40	122.37	17	1757
	NW-CO	217.44	130.36	19	2591
	US-AA	222.54	122.48	16	1797
AM_{irt} (%)	DL-UA	11.66	14.33	0.2	85.5
	NW-CO	13.55	13.53	0.4	83.1
	US-AA	14.31	16.11	0.4	84.1
MS_{irt} (%)	DL-UA	19.45	27.54	0.1	100
	NW-CO	19.05	27.56	0.1	100
	US-AA	19.57	27.39	0.1	100
$DIST_r$	DL-UA	1183.19	672.99	67	2704
	NW-CO	989.12	587.85	17	2565
	US-AA	1021.65	655.16	67	2724
$lagMS_{irt}$ (%)	DL-UA	18.88	26.76	0.1	100
	NW-CO	13.93	24.85	0	100
	US-AA	14.2	24.98	0	100
Completion Effect					
$Fare_{irt}$	DL-UA	200.13	122.49	18	1757
	NW-CO	210.35	121.19	19	1710
	US-AA	210.19	114.77	15	1797
AM_{irt} (%)	DL-UA	12.27	14.68	0.1	88.6
	NW-CO	13.52	13.42	0.2	88.6
	US-AA	14.3	15.63	0.2	96.7
MS_{irt} (%)	DL-UA	19.46	27.51	0.1	100
	NW-CO	19.34	27.72	0.1	100
	US-AA	19.47	27.08	0.1	100

Table 4.2 (cont'd).

Variable	Network	Mean	s.e.	Min.	Max.
$DIST_r$	DL-UA	1174.86	673.21	30	2704
	NW-CO	989.12	587.85	17	2565
	US-AA	1021.65	655.16	67	2724
$lagMS_{irt}$ (%)	DL-UA	19.46	27.55	0.1	100
	NW-CO	11.11	23.09	0	100
	US-AA	9.88	20.75	0	100
Number of Aliance Routes[b]	DL-UA	691			
	NW-CO	476			
	US-AA	469			
N (Number of Observations on Network)	DL-UA	18,657			
	NW-CO	12,852			
	US-AA	12,663			

(a) See Chapter 3, Section 3.7 for time period description and Table 4.1 for Variable Definitions.
(b) The data set is balanced.

4.4 Evidence: Pooled OLS Estimates of the Impact of Alliance Formation on Airport Dominance

Table 4.3 bears the pooled OLS estimation results, where the impact of alliance formation ($ALLY_{irt}$) on airport dominance (AM_{irt}) is noted after controlling for the influences of gate constraints/slot controls (*Gate/Slot*$_r$) and for the geographical 'isolation' of at least one endpoint airport ($ARPT_r$).

Parameter estimates in the first column of Table 4.3 show the dramatic positive impact that alliance formation ($ALLY_{irt}$) had on changes in airport dominance (AM_{irt}) on our sample of some of the busiest airports in the country.[103] Specifically, and for instance for the full effect of the Northwest-Continental alliance, participation in this alliance was associated with a 52% increase in airport dominance.

[103] Appendix B lists the 45 busiest airports of the country.

Table 4.3: Pooled OLS[a] Estimates of log (AM_{irt}).[b]

Dependent Variable: log (AM_{irt})	Network:	$ALLY_{irt}$	MS_{irt}	Gate/Slot $_r$	$ARPT_r$	D2	D3	Constant	R^2	N
Full Effect	DL-UA	0.5143*	0.0248*	-0.0412*	-0.0144	-0.2916*	-0.0335*	1.7402	0.5607	18,657
		(0.0232)	(0.0002)	(0.0144)	(0.0191)	-0.0191	(0.0162)	(0.0224)		
	NW-CO	0.5259*	0.0192*	-0.0438*	0.0475**	-0.1077	-0.0998*	2.0244	0.5181	12,852
		(0.0259)	(0.0003)	(0.0149)	(0.0219)	(0.0199)	(0.0185)	(0.0264)		
	US-AA	0.7230*	0.0204*	-0.0082	0.0183	-0.1488*	-0.1295*	1.8745	0.5276	12,663
		(0.0257)	(0.0003)	(0.0164)	(0.0287)	(0.0207)	(0.0221)	(0.0322)		
Announcement Effect										
	DL-UA	0.1905*	0.0261*	-0.0384*	-0.0100	-0.2296*	-	1.7096	0.5101	11,826
		(0.0333)	(0.0003)	(0.0187)	(0.0251)	(0.0201)		(0.0273)		
	NW-CO	0.4693*	0.0203*	-0.0490*	0.0393***	-0.0978	-	2.0155	0.4980	8568
		(0.0360)	(0.0003)	(0.0187)	(0.0274)	(0.0204)		(0.0314)		
	US-AA	0.6987*	0.0237	0.0059	0.0493	-0.1254*	-	1.7754	0.5621	8442
		(0.0364)	(0.0003)	(0.0195)	(0.0341)	(0.0212)		(0.0366)		
Completion Effect										
	DL-UA	0.8726*	0.0226*	-0.0447*	-0.0029	-	0.0911*	1.5806	0.5586	11,826
		(0.0256)	(0.0003)	(0.0174)	(0.0230)		(0.0174)	(0.0253)		
	NW-CO	0.5176*	0.0195*	-0.0388**	0.0631	-	-0.0898*	1.9939	0.5029	8568
		(0.0325)	(0.0003)	(0.0187)	(0.0279)		(0.0198)	(0.0327)		
	US-AA	0.7705*	0.0211*	-0.0106*	-0.0017	-	-0.1234*	1.8861	0.4867	8442
		(0.0350)	(0.0004)	(0.0208)	(0.0361)		(0.0231)	(0.0390)		

(a) With heteroskedasticity robust standard errors.

(b) See Table 4.1 for explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

Note that the magnitude of the Alliance Participation dummy variable ($ALLY_{irt}$) noted in the full effect period was lead by its large changes in the period corresponding to full fledged alliance operations (that is, in the completion effect) for all three alliances, though the changes in airport dominance due to alliance announcement were also not trivial by any standard.

The third column of Table 4.3 shows that the parameter estimates of the gate constraint/slot control explanatory variable (*Gate/Slot*$_r$) is consistently negative when statistically significant, indicating that the scarcity of this physical resource had placed limits on changes in airport dominance at such airports and over the time period examined. [104]

Parameter estimates of route market share (MS_{irt}) were unsurprisingly positive and maintained statistical significance throughout, showing the strong and positive association between route and airport level dominance. Parameter estimates of the dummy variable controlling for the 'isolation' of at least one endpoint airport ($ARPT_r$) was positive when statistically significant, showing that when an airport enjoyed such singularity in a given metropolitan area, that it was associated with greater airport dominance.

4.5 Some Econometric Issues

4.5.1 Collinearity Between Explanatory Variables

Collinearity between route market share (MS_{irt}) and the Alliance Participation dummy variable ($ALLY_{irt}$) was suspected. In Appendix F, pooled OLS estimation results

[104] Evans and Kessides (1993) find that airport capacity constraints augment a carrier's market power.

of the impact of alliance formation on airport dominance (AM_{irt}) are reported if Route Market Share (MS_{irt}) is *excluded* as an explanatory variable.

A comparison of the pooled OLS estimation results in Table 4.3 with those in Appendix F shows that while the inclusion of Route Market Share (MS_{irt}) as an explanatory variable in the former, reduced the quantitative impact of the Alliance Participation dummy variable ($ALLY_{irt}$) and its standard error was larger, there was no qualitative change: it remained both large in magnitude and significant statistically in its association with airport dominance (AM_{irt}).

Pooled OLS parameter estimates of the Alliance Participation dummy variable ($ALLY_{irt}$) in Table 4.3 range from 72% for the US Airways-American alliance to 51% for the Delta-United alliance. A comparison of the magnitude of these parameter estimates with those in Appendix F, indicates that changes in the dependent variable (AM_{irt}) are not captured entirely by changes in route level dominance (MS_{irt}) but rather, the impact of alliance participation on the dependent variable is important.

4.5.2 The Omitted Variables Problem

Recall from Chapter 3 (Section 3.9) that pooled OLS estimation may result in inconsistent parameter estimates due to the omitted variables problem. Specifically, this estimation method ignores the impact of time constant unobserved effects on the dependent variable. There may be some market specific and/or firm specific characteristics that affect a carrier's ability to dominate an airport, and these influences have so far been relegated to the idiosyncratic error term (U_{irt} in equation 3.3). Therefore, a method within the class of models of unobserved heterogeneity is appropriate, where such unobserved effects are explicitly accounted for.

In terms of airport dominance changes, the basic model of unobserved heterogeneity is:

$$\ln AM_{irt} = X_{irt}\,\beta + U_{irt} + C_{ir} \tag{4.1}$$

Where X_{irt} is the vector of regressors (listed earlier in Section 4.3), C_{ir} is the *unobserved heterogeneity* that captures the qualitative unobserved and time invariant influences on airport dominance. U_{irt} is the idiosyncratic error.

4.5.3 Endogeneity of an Explanatory Variable

Endogeneity of Route Market Share (MS_{irt}) was suspected and confirmed on each route network.[105] Since the strict exogeneity condition on the explanatory variables fails if C_{ir} (the unobserved heterogeneity term in equation 4.1) is correlated with any element of the vector X_{irt},, the first step is to adopt a more appropriate estimation method.

If the noted endogeneity of Route Market Share (MS_{irt}) is due to its correlation with C_{ir}, then this problem can be mitigated by the adoption of first differencing (FD), a method within the class of models of unobserved heterogeneity. The FD method allows for arbitrary correlation between C_{ir} and X_{irt} and the FD transformation eliminates the unobserved effect C_{ir}.[106]

[105] On the Delta-United alliance network, the estimate of the reduced form residual was 0.0248, with a t-statistic of 87.03 and a p-value of 0. Endogeneity of route market share was similarly found on Northwest-Continental and on US Airways-American alliance networks.

[106] Recall from Chapter 3 that the FD method falls within the class of models of unobserved heterogeneity that allow us to control for the effects of unobservable firm level factors such as managerial quality, and route level factors such as the 'mix' of passengers between leisure and business types, on the dependent variable.

Recall from Chapter 3 (Section 3.9) that the FD transformation lags the elements of the dependent and independent variables and subtracts them. If two quarters are considered, that is t = 2, then equation 4.1 becomes:

$$\Delta \ln AM_{irt} = \theta_2 + \Delta X_{irt}\beta + \Delta U_{irt} \tag{4.2}$$

where $\Delta \ln AM_{irt} = \ln AM_{irt} - \ln AM_{ir,t-1}$ and θ_2 is the second period intercept.

4.6 Preliminary Evidence: First Difference Estimates of the Impact of Alliance Formation on Airport Dominance

Table 4.4 shows parameter estimates after the FD transformation. Recall that time invariant explanatory variables cannot be estimated as these are not distinguishable from C_{ir} (in equation 4.1) and are dropped after the FD transformation.

First differencing parameter estimates in Table 4.4 re-confirm that alliance participation ($ALLY_{irt}$) had a positive and large impact on the growth in the airport dominance gap at some of the most important airports of the country. For instance, for the Delta-United alliance, results in the first column of Table 4.4 show that in the full effect period, the growth in the airport dominance gap between alliance participant and non-participant firms was 31%.

While the sign of the parameter estimate of the Alliance Participation dummy variable ($ALLY_{irt}$) from pooled OLS estimation (Table 4.3) is not different from that after the FD transformation (Table 4.4), its magnitude is now much lower. For instance, for the Northwest-Continental alliance in the full effect period, alliance participation was associated with a 52% higher (average) airport dominance as compared to the 28%

growth in the airport dominance gap shown in Table 4.4. These large differences in the magnitude of the parameter estimate of prime interest points to the importance of controlling for unobserved heterogeneity at the route and firm level when examining this relationship. The message though, remained unaltered: airline cooperation through the formation of domestic alliances has lead to the widening of the gap in airport dominance between firms entering these agreements and those remaining outside them at some of the busiest airports of the country.

Table 4.4 also shows that that a positive and significant effect on the growth in the airport dominance gap due to alliance participation ($ALLY_{irt}$) existed even before these alliance had actually formed (that is, in the alliance announcement effect period).[107] For instance, the first column of Table 4.4 shows that just announcement of participation in the Northwest-Continental alliance was associated with a 22% increase in the airport dominance gap between this alliance and its rival carriers.[108] For US Airways-American, the results are even stronger in magnitude: the announcement of this alliance was associated with a 67% growth in its airport dominance gap.[109]

Comparing the pooled OLS parameter estimates for the explanatory variable that is a proxy for the impact of route level dominance (MS_{irt}) in Table 4.3, with the first differencing parameter estimates in Table 4.4 shows that its quantitative and qualitative impact remained unchanged between the two estimation methods.

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107 Except for Delta-United, for which the Alliance Participation dummy variable was not statistically significant in the announcement effect period.

108 Recall from Chapter 3, Table 3.4 that the growth in the fare gap during the announcement effect period for the Northwest-Continental alliance was not statistically significant.

109 These pre-alliance results are not surprising if passengers had responded to the 'benefits' offered by the alliances even before they were up and running. One important way this may have been possible is though the merger of the Frequent Flyer Programs: alliance forming carriers had declared their intentions to acknowledge even previously accumulated mileage on their partner carrier's flights. See "Marriages of Convenience", Frequent Flyer, Page 16, July 1998.

Table 4.4: First Difference[a] Estimates of log (AM_{irt}).[b]

Dependent Variable: log (AM_{irt})		$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
	Network:							
Full Effect	DL-UA	0.3133*	0.0217*	0.1712*	0.0791*	-0.1000	0.4173	18,657
		(0.0283)	(0.0004)	(0.0306)	(0.0278)	(0.0194)		
	NW-CO	0.2859*	0.0193*	0.0248	0.0044	-0.1477*	0.3813	12,852
		(0.0369)	(0.0004)	(0.0435)	(0.0407)	(0.0295)		
	US-AA	0.5463*	0.0231*	0.1295*	0.1498*	-0.4198	0.4617	12,663
		(0.0509)	(0.0006)	(0.0443)	(0.0484)	(0.0322)		
Announcement Effect								
	DL-UA	-0.0407	0.0223*	0.0919*	-	-0.0872*	0.3765	11,826
		(0.0402)	(0.0005)	(0.0313)		(0.0199)		
	NW-CO	0.2226*	0.0198*	0.0139	-	-0.1450	0.3658	8568
		(0.0481)	(0.0005)	(0.0453)		(0.0304)		
	US-AA	0.6756*	0.0264*	0.1420	-	-0.3728	0.5345	8442
		(0.0634)	(0.0006)	(0.0459)		(0.0325)		
Completion Effect								
	DL-UA	0.7085*	0.0189*	-	0.0682*	-0.0243	0.4042	11,826
		(0.0327)	(0.0004)		(0.0307)	(0.0224)		
	NW-CO	0.3238*	0.0193*	-	0.0503	-0.1854	0.3733	8568
		(0.0484)	(0.0005)		(0.0440)	(0.0327)		
	US-AA	0.4498*	0.0239*	-	0.1571*	-0.4766	0.4156	8442
		(0.0759)	(0.0007)		(0.0527)	(0.0340)		

(a) With heteroskedasticity robust standard errors.

(b) See Table 4.1 for explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

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4.7 The Persistent Endogeneity of the Explanatory Variable

The simple FD transformation provides consistent parameter estimates only if (the changes in) X_{irt} and U_{irt} (in equation 4.1) are orthogonal. But if the problem was contemporaneous endogeneity, it will exist even after the FD transformation and the parameter estimates in Table 4.4 will still not be consistent: strict exogeneity requires that the explanatory variables in each time period be uncorrelated with the idiosyncratic error (U_{irt}) in each time period.[110]

The persistent endogeneity of Route Market Share (MS_{irt}) was established on each alliance network.[111] Therefore, in order to mitigate this econometric problem, an appropriate instrument is needed. A valid instrument (IV) is one that satisfies two conditions: first, it should have some partial correlation with the endogenous explanatory variable (MS_{irt}), given the other variables, and second, it should be orthogonal to the idiosyncratic error (U_{irt}).

The two period lagged route market share (lag MS_{irt} and defined earlier in Table 4.1) was selected as an appropriate instrument as it seemed reasonable to expect a positive correlation between this and a firm's route market share (MS_{irt}) and of its orthogonality to the time-varying error U_{irt}.[112] The selection of this instrument indicates the assumption that a *two* period lag is sufficient to control for any dynamic effects.

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[110] See Wooldridge 2002.

[111] For instance, on the Delta-United network, reduced form residual estimate was 0.0217 with a t statistic of 57.44 and a P-value of 0. The test of endogeneity on the networks of the other two alliances yielded qualitatively similar results. Note that a *positive* correlation between route market share and the time-varying error will overestimate the impact of this explanatory variable on the dependent variable.

[112] An alternative instrument that can be employed for the endogenous route market share is its Rank, defined earlier in Table 4.1. This is the instrument used by Evans and Kessides (1993) and is constructed so that the firm with the largest route market share has a Rank of 1, while that with the smallest route market share has a Rank of 8. Parameter estimates obtained with Rank as an instrument were qualitatively similar to those in Table 4.4. Therefore only results using the two-period lagged route market share instrument are shown and discussed.

Estimation results after the FD transformation and the instrumentation of the endogenous explanatory variable are discussed next.

4.8 Evidence: First Difference-2SLS Estimates of the Impact of Alliance Formation on Airport Dominance

Given the lingering endogeneity of route market share (MS_{irt}) after the FD transformation, the relation between Alliance participation ($ALLY_{irt}$) and airport dominance (AM_{irt}) is examined with the two period lagged route market share (lag MS_{irt}) as an instrument for the endogenous explanatory variable.

Table 4.5 shows these results on the three alliance networks, again as the announcement, completion and full effects. A comparison of the results in Table 4.5 with those after the simple FD transformation in Table 4.4, shows that instrumentation of the endogenous explanatory variable made a difference: parameter estimates of the explanatory variable of primary interest (that is, $ALLY_{irt}$) were smaller in magnitude in Table 4.5. Standard errors after the simple FD transformation (in Table 4.4) were larger than after pooled OLS estimation (Table 4.3) and larger still after the instrumentation of the endogenous explanatory variable (Table 4.5). Between these three alternative estimation methods however, parameter estimates of the Alliance Participation dummy variable ($ALLY_{irt}$) remained both strong in magnitude and statistically significant at the 1% level.

Table 4.5: First Difference-2SLS Estimates of log (AM_{irt}),[a] lag (MS_{irt}) as Instrument.[b]

Dependent Variable: log (AM_{irt})	Network:	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
Full Effect	DL-UA	0.2783*	0.0228*	0.1710*	0.0753*	-0.1001	0.4235	18,657
		(0.0300)	(0.0004)	(0.0316)	(0.0287)			
	NW-CO	0.1439*	0.0217*	-0.0019	-0.0257	-0.1190*	0.3779	12,852
		(0.0422)	(0.0006)	(0.0440)	(0.0413)	(0.0301)		
	US-AA	0.4732*	0.0278*	0.1189*	0.0322	-0.3490	0.4707	12,663
		(0.0641)	(0.0006)	(0.0453)	(0.0517)	(0.0320)		
Announcement Effect								
	DL-UA	-0.0738**	0.0231*	0.0912*	-	-0.0910	0.3838	11,826
		(0.0414)	(0.0005)	(0.0323)		(0.0202)		
	NW-CO	0.1401*	0.0216*	-0.0062	-	-0.1236	0.3639	8568
		(0.0514)	(0.0006)	(0.0457)		(0.0307)		
	US-AA	0.6180*	0.0276*	0.1252*	-	-0.3536	0.5333	8442
		(0.0665)	(0.0007)	(0.0459)		(0.0325)		
Completion Effect								
	DL-UA	0.6848*	0.0200*	-	0.0590**	-0.0160	0.4143	11,826
		(0.0348)	(0.0005)		(0.0318)	(0.0232)		
	NW-CO	0.1414**	0.0233*	-	0.0063	-0.1411	0.3632	8568
		(0.0607)	(0.0008)		(0.0452)	(0.0337)		
	US-AA	0.3418*	0.0310*	-	0.0517	-0.3653	0.4266	8442
		(0.2616)	(0.0008)		(0.0529)	(0.0339)		

(a) With heteroskedasticity robust standard errors.
(b) See Table 4.1 for explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.
*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

The results in Table 4.5 again show that domestic alliance participation ($ALLY_{irt}$) provided a direct and strong explanation for the growth in the gap in airport dominance between alliance participant and non-participant firms, over the time periods considered and on some of the busiest airports of the country. For instance, from the first column of Table 4.5 and for the full effect of the Northwest-Continental alliance, results show that participation in this alliance allowed the airport dominance gap between alliance and rival firms to grow 14% between the three time periods examined.[113]

For the Delta-United and US Airways-American alliances, this parameter estimate was even stronger in magnitude: the former alliance is associated with a 28% increase in the airport dominance gap and the latter, with a 47% growth in this gap. Except for the US Airways-American alliance, this result was driven by strong announcement effect parameter estimates.

Next, Table 4.6 shows hub-specific FD-Two Stage Least Squares (2SLS) estimation results for the impact of alliance formation on the growth in the airport dominance gap there. Parameter estimates of the alliance participation dummy variable ($ALLY_{irt}$) were qualitatively similar to those discussed in reference to Table 4.5.[114]

[113] With respect to the statistically significant negative Alliance Participation dummy variable for the Delta-United alliance in its announcement period, recall from Chapter 3 (section 3.6.1) that this is not interpretable as the realization of improved efficiency, since in this period the alliance had not yet begun operations.

[114] At the Houston (IAH) hub of Northwest-Continental, alliance formation was associated with a decrease in the airport dominance gap between alliance forming and rival firms. Recall that pooled OLS results in Appendix E identified Houston (IAH) as the Northwest-Continental hub at which improved efficiency was realized due to alliance formation.

Table 4.6: Hub Specific First Difference-2SLS[a] Estimates of log (AM_{irt}),[b] with lag (MS_{irt}) as Instrument.

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
A.Delta-United:							
Full Effect							
Atlanta (ATL)	-0.3320**	0.0292*	0.0952	-0.0473	-0.0379	0.4970	2106
	(0.1525)	(0.0020)	(0.1046)	(0.0862)	(0.0616)		
Cincinnati (CVG)	-0.0677	0.0275*	0.1830	-0.0894	0.0307	0.6446	2106
	(0.1979)	(0.0016)	(0.1457)	(0.1315)	(0.0876)		
Denver (DEN)	-0.0348	0.0267*	0.1796	-0.0128	-0.0723	0.4345	2106
	(0.1546)	(0.0020)	(0.0987)	(0.0917)	(0.0670)		
Dallas (DFW)	0.2958**	0.0171*	0.1703**	0.0986	-0.0845	0.1677	2079
	(0.1205)	(0.0019)	(0.0967)	(0.0959)	(0.0628)		
Dulles (IAD)	0.3214**	0.0209*	0.3538*	0.1589***	-0.0061	0.3802	1998
	(0.1497)	(0.0018)	(0.1187)	(0.1161)	(0.0701)		
Los Angeles (LAX)	0.3184*	0.0226*	0.0697	0.0627	-0.0442	0.3780	2106
	(0.0501)	(0.0012)	(0.0658)	(0.0558)	(0.0428)		
Chicago (ORD)	0.1607**	0.0182*	0.1321***	-0.0096	-0.0281	0.2655	2052
	(0.0836)	(0.0019)	(0.0864)	(0.0773)	(0.0489)		
San Francisco (SFO)	0.3775*	0.0276*	0.1083***	0.1021***	-0.0777	0.4789	1998
	(0.0857)	(0.0013)	(0.0712)	(0.0665)	(0.0473)		
Salt Lake City (SLC)	0.1990**	0.0217*	0.1114	0.0424	-0.2135	0.4059	2106
	(0.1007)	(0.0019)	(0.0885)	(0.0831)	(0.0588)		
Announcement Effect							
Atlanta (ATL)	-0.5522*	0.0274*	0.0449	-	-0.0773	0.4496	1404
	(0.1961)	(0.0022)	(0.1134)		(0.0649)		
Cincinnati (CVG)	-0.4148***	0.0278*	0.0364	-	0.0392	0.6276	1404
	(0.2565)	(0.0017)	(0.1602)		(0.0881)		

Table 4.6 (cont'd).

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
Denver (DEN)	-0.4398**	0.0269*	0.0587	-	-0.0707	0.4139	1404
	(0.1898)	(0.0023)	(0.1048)		(0.0704)		
Dallas (DFW)	0.0441	0.0149*	0.0779	-	-0.0517	0.1631	1386
	(0.1788)	(0.0021)	(0.1079)		(0.0667)		
Dulles (IAD)	-0.0075	0.0193*	0.2476**	-	-0.0038	0.3512	1332
	(0.1954)	(0.0021)	(0.1285)		(0.0738)		
Los Angeles (LAX)	-0.0185	0.0212*	0.0293	-	-0.0321	0.3252	1404
	(0.0644)	(0.0018)	(0.0660)		(0.0439)		
Chicago (ORD)	-0.1756***	0.0182*	0.0142	-	-0.0188	0.2449	1368
	(0.1255)	(0.0025)	(0.0945)		(0.0505)		
San Francisco (SFO)	-0.0639	0.0279*	0.0095	-	-0.0276	0.4381	1332
	(0.0985)	(0.0016)	(0.0726)		(0.0500)		
Salt Lake City (SLC)	-0.0831	0.0210*	0.1026	-	-0.2328	0.3574	1404
	(0.1202)	(0.0022)	(0.0880)		(0.0593)		
Completion Effect							
Atlanta (ATL)	0.5911*	0.0201*	-	0.0931	-0.0905	0.4191	1404
	(0.1810)	(0.0023)		(0.1059)	(0.0789)		
Cincinnati (CVG)	0.7079*	0.0214*	-	0.0475	0.0211	0.6082	1404
	(0.2140)	(0.0017)		(0.1585)	(0.1132)		
Denver (DEN)	0.5281*	0.0236*	-	-0.0263	0.0631	0.4178	1404
	(0.1774)	(0.0022)		(0.1054)	(0.0769)		
Dallas (DFW)	0.4897*	0.0177*	-	0.1080	-0.0297	0.1588	1386
	(0.1299)	(0.0023)		(0.1118)	(0.0786)		
Dulles (IAD)	0.7559	0.0205*	-	0.0252	0.2447	0.3549	1332
	(0.1923)	(0.0025)		(0.1348)	(0.0856)		

Table 4.6 (cont'd).

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
Los Angeles (LAX)	0.0229*	0.6472*	-	0.0332	0.0101	0.3886	1404
	(0.0015)	(0.0584)		(0.0615)	(0.0505)		
Chicago (ORD)	0.5361*	0.0167*	-	0.0838	-0.0079	0.2358	1368
	(0.0926)	(0.0021)		(0.0884)	(0.0572)		
San Francisco (SFO)	0.8704*	0.0250*	-	0.0924	-0.0219	0.4934	1332
	(0.1130)	(0.0017)		(0.0701)	(0.0514)		
Salt Lake City (SLC)	0.6263*	0.0189*	-	-0.0294	-0.1270	0.4160	1404
	(0.1159)	(0.0022)		(0.0857)	(0.0640)		
B. Northwest-Continental:							
Full Effect							
Cleveland (CLE)	0.1299**	0.0214*	0.0001	-0.0389	-0.0640	0.4752	2133
	(0.0726)	(0.0009)	(0.0793)	(0.0769)	(0.0563)		
Detroit (DTW)	0.0218	0.0238*	-0.0874	-0.0910	-0.0980	0.4350	2160
	(0.1198)	(0.0015)	(0.1052)	(0.1036)	(0.0754)		
Houston (IAH)	0.3913**	0.0208*	0.0529	0.0704	-0.1602	0.2863	2160
	(1874)	(0.0020)	(0.1993)	(0.1613)	(0.0997)		
Memphis (MEM)	0.3917**	0.0174*	0.0862	0.0442	-0.1423	0.3355	2133
	(0.1553)	(0.0020)	(0.1691)	(0.1435)	(0.1168)		
Minneapolis (MSP)	0.2949*	0.0213*	-0.0326	0.0010	-0.1123	0.3802	2187
	(0.0766)	(0.0012)	(0.0858)	(0.0849)	(0.0617)		
Newark (EWR)	-0.1831***	0.0254*	0.0191	-0.0816	-0.2245	0.3381	2079
	(0.1259)	(0.0017)	(0.1129)	(0.0980)	(0.0666)		
Announcement Effect							
Cleveland (CLE)	0.0902	0.0219*	-0.0065	-	-0.0582	0.4636	1422
	(0.0923)	(0.0010)	(0.0810)		(0.0587)		

Table 4.6 (cont'd).

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
Detroit (DTW)	-0.0372	0.0241*	-0.1060	-	-0.0932	0.4304	1440
	(0.1447)	(0.0014)	(0.1118)		(0.0755)		
Houston (IAH)	0.2294	0.0210*	-0.0225	-	-0.1571	0.2506	1420
	(0.2695)	(0.0022)	(0.2384)		(0.1047)		
Memphis (MEM)	0.4612**	0.0151*	0.1255	-	-0.2067	0.2988	1422
	(0.1966)	(0.0017)	(0.1891)		(0.1087)		
Minneapolis (MSP)	0.2269**	0.0219*	-0.0265	-	-0.1191	0.3821	1458
	(0.0967)	(0.0013)	(0.0854)		(0.0608)		
Newark (EWR)	-0.2163	0.0257*	0.0020	-	-0.2126	0.3295	1386
	(0.1709)	(0.0018)	(0.1249)		(0.0683)		
Completion Effect							
Cleveland (CLE)	0.0873	0.0225*	-	-0.0398	-0.0615	0.4578	1422
	(0.1026)	(0.0013)		(0.0786)	(0.0580)		
Detroit (DTW)	0.1952	0.0218*	-	0.0554	-0.2272	0.4180	1440
	(0.1729)	(0.0022)		(0.1171)	(0.0840)		
Houston (IAH)	0.4498**	0.0232*	-	0.2174	-0.2390	0.2769	1440
	(0.2511)	(0.0035)		(0.2095)	(0.1519)		
Memphis (MEM)	0.1826	0.0215*	-	0.0257	-0.1164	0.3273	1422
	(0.2133)	(0.0029)		(0.1707)	(0.1433)		
Minneapolis (MSP)	0.2764**	0.0239*	-	0.0275	-0.1299	0.3590	1458
	(0.1186)	(0.0019)		(0.0903)	(0.0673)		
Newark (EWR)	-0.1604	0.0252*	-	-0.1034	-0.1995	0.3183	1386
	(0.1570)	(0.0020)		(0.1084)	(0.0766)		

Table 4.6 (cont'd).

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
C. US Airways-American:							
Full Effect							
Charlotte (CLT)	0.8490*	0.0188*	-0.0209*	0.0196*	0.1957	0.5667	2533
	(0.0072)	(0.0008)	(0.0059)	(0.0620)	(0.0485)		
Dallas (DFW)	0.01210	0.0293*	0.0044	0.0114**	0.1632	0.5839	2506
	(0.0088)	(0.0012)	(0.0043)	(0.0048)	(0.0475)		
Miami (MIA)	0.5105*	0.0171*	-0.0188*	-0.0188*	0.0204	0.5114	2425
	(0.0045)	(0.0007)	(0.0045)	(0.0045)	(0.0343)		
Chicago (ORD)	0.4662*	0.0268*	-0.0123*	-0.0142*	0.1774	0.5414	295
	(0.0048)	(0.0008)	(0.0043)	(0.0047)	(0.0479)		
Philadelphia (PHL)	0.6214*	0.0181*	-0.0149*	-0.0127**	0.1859	0.5360	2452
	(0.0057)	(0.0007)	(0.0048)	(0.0053)	(0.0409)		
Pittsburgh (PIT)	0.7047*	0.0177*	-0.0219*	-0.0179*	0.1611	0.5643	2452
	(0.0074)	(0.0008)	(0.0057)	(0.0000)	(0.0302)		
Announcement Effect							
Charlotte (CLT)	0.5273*	0.0221*	-0.0166*	-	0.1879	0.5887	1692
	(0.0010)	(0.0009)	(0.0026)		(0.0496)		
Dallas (DFW)	0.1932	0.0308*	-0.0002	-	0.1602	0.6317	1674
	(0.1140)	(0.0014)	(0.0047)		(0.0512)		
Miami (MIA)	0.6944*	0.0207*	-0.0160*	-	0.1976	0.5564	1620
	(0.0064)	(0.0008)	(0.0040)		(0.0344)		
Chicago (ORD)	0.5005*	0.0307*	-0.0112*	-	0.1683	0.6045	198
	(0.0071)	(0.0009)	(0.0045)		(0.0517)		
Philadelphia (PHL)	0.7663*	0.0220*	-0.0122*	-	0.1779	0.5749	1638
	(0.0082)	(0.0008)	(0.0049)		(0.0413)		

Table 4.6 (cont'd).

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
Pittsburgh (PIT)	0.7880*	0.0211*	-0.0186*	-	0.1337	0.5279	1638
	(0.0100)	(0.0009)	(0.0059)		(0.0261)		
Completion Effect							
Charlotte (CLT)	0.4436*	0.0205*	-	-0.0156*	0.1903	0.5605	1692
	(0.0094)	(0.0009)		(0.0064)	(0.0484)		
Dallas (DFW)	0.0689	0.0296*	-	0.0114**	0.1640	0.5605	1674
	(0.0087)	(0.0011)		(0.0051)	(0.0566)		
Miami (MIA)	0.3893*	0.0280*	-	-0.0163*	0.2016	0.4534	1620
	(0.0065)	(0.0009)		(0.0048)	(0.0359)		
Chicago (ORD)	0.4263*	0.0259*	-	-0.0139*	0.1805	0.4862	198
	(0.0067)	(0.0010)		(0.0050)	(0.0568)		
Philadelphia (PHL)	0.4993*	0.0180*	-	-0.0163*	0.1898	0.4799	1638
	(0.0080)	(0.0009)		(0.0055)	(0.0413)		
Pittsburgh (PIT)	0.6220*	0.0195*	-	-0.0152*	0.1840	0.5395	1638
	(0.0099)	(0.0009)		(0.0059)	(0.0921)		

(a) With heteroskedasticity robust standard errors.
(b) See Table 3.2 for explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.
*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

4.9 Synopsis and Conclusion

After the satisfaction in Chapter 3 of the hypothesis of the attainment of efficiency improvements versus the exercise of market power following the formation of the three major domestic alliances, in this chapter the relationship between this event and the changes in airport dominance that it had permitted was examined. The query had proceeded in this direction since it was confirmed that the power over fare changes due to alliance formation that was found in Chapter 3, was conveyed primarily through the control of airport facilities. Specifically, it was noted that when a proxy for airport dominance (AM_{irt}) was added as an explanatory variable in the price equation, the magnitude of the Alliance Participation dummy variable ($ALLY_{irt}$) decreased.

In this chapter, parameter estimates from alternative methods of estimation adopted to contend with some econometric issues, all continually conveyed the same message: domestic alliance formation explained a dramatically increasing airport dominance gap between firms participating in these arrangements and those remaining outside them, at some of the most important airports of the country.

Chapter 5. Sub-Sample Analysis: Disentangling the Market Power

Results from the adoption of alternative methods of estimation in Chapter 3 yielded a consistent and strong answer to our primary hypothesis of increased efficiency versus increased market power: on some of the most important routes in the country the formation of domestic alliances, causing pairings between the six most dominant carriers, had lead to these carriers enjoying the spoils of increased market power. The increased market power realized by firms participating in domestic alliances could have been made possible due to the alliance allowing a reduction in the number of rival firms by one, *or* due to advantages accruing to a firm now operating at a larger size. This defines the hypothesis of this chapter and the clarification of this obscurity is its main purpose.

5.1 The Price Equation

Recall that the price equation in Chapter 3 (section 3.1) was derived from the model of profit maximization in Chapter 2 (section 2.1) and it relates the log of average fares ($lfare_{irt}$) to alliance formation and to other variables that form the vector of structural variables X_{irt}.[115] That is,

$$\ln P_{irt} = X_{irt}\,\beta + U_{irt} \tag{5.1}$$

The explanatory variable of prime interest is the Alliance Participation dummy variable ($ALLY_{irt}$), defined as one if the firm is a member of the domestic alliance in question and zero otherwise.

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[115] Dependent and explanatory variables were defined earlier Section 3.2 of Chapter 3 and in Table 3.2.

5.2 Hypotheses Tests on Route Sub-Samples

The full route sample will be divided into overlapping and non-overlapping routes. The former are defined simply as those routes on which both firms participating in an alliance operated during each time period considered. Similarly, non-overlapping routes are those on which at most one firm participating in the alliance operated at each time period considered.

On our sample of routes between each hub airport and the 45 busiest airports of the country, the majority of the routes were served by ***one or the other*** alliance partner: only about 19% of the total sample of routes was served by both members of the Delta-United alliance during the time periods corresponding to alliance announcement and formation. For both Northwest-Continental and US Airways-American, overlapping routes were only 3% of our total route sample.

5.2.1 Efficiency versus Market Power

First, it will be interesting to see whether any notable magnitude changes take place in the Alliance Participation dummy variable ($ALLY_{irt}$) on these route sub-samples from those noted earlier in Chapter 3 (section 3.10) for the full route sample. Thus our primary hypothesis of efficiency versus market power (detailed earlier in Chapter 3) will be re-examined here for the two most important route sub-samples. If the magnitude of $ALLY_{irt}$ increases, for instance on alliance overlapping routes from that noted earlier in Chapter 3 (section 3.10) for the full sample, it will show that domestic alliance participation was more effective in increasing the growth of the price gap on their overlapping routes than it was on the total sample.

It is important to note at this point that the potential for the realization of improved efficiency/cost synergies or of increased market power exists on both overlapping and on non-overlapping routes.

For instance, on their overlapping routes, alliance formation has a potential for the creation of efficiencies through the reduction of redundancies between the partner firms. The dominance of this effect (captured by a lower B^c_{irt} in terms of our structural model of profit maximization in Chapter 2) should *lower* the growth of the post alliance price gap (that is, $ALLY_{irt} < 0$) between alliance forming firms and their rivals.

On the other hand, it is on these overlapping routes that there has been a direct reduction in the number of competing firms. Here, the power to raise fares after alliance formation could have been derived by the conversion of a former competitor to an ally, that is, due to the reduction in the number of rival firms by one. The two firms that formerly competed directly may now have greater opportunity, incentive and power to collude on their overlapping markets, especially if the services of the two alliance member firms are now perfect (or near perfect) substitutes to an important (and lucrative) segment of demand. Evidence of the dominance of these factors (captured by a higher A^d_{irt} in terms of our structural model of profit maximization in Chapter 2) will be a positive Alliance Participation dummy variable ($ALLY_{irt} > 0$) showing a positive growth in the price gap between alliance forming firms and their rival carriers.

On their non-overlapping routes, alliance membership advantages can accrue due to the firm now operating at a larger size or through multi-market contact. There may even be some scope for the realization of cost synergies to the extent that the distinct routes are being served from common airports and where on-ground cost synergies can be feasibly achieved.

5.2.2 Size versus Concentration

The test of the sub-sample hypothesis requires a comparison of the sign and magnitude of the Alliance Participation dummy variable ($ALLY_{irt}$) on the two route sub-samples. The parameter estimate of the Alliance Participation dummy variable ($ALLY_{irt}$) may be greater in magnitude on non-overlapping routes than when the sub-sample is restricted only to alliance overlapping routes. This will show that since domestic alliance formation had a greater impact on the growth in the price gap on their complementary route system, that the greater market power was derived due to an increase in the size of the firm.[116]

Conversely, the parameter estimate of the Alliance Participation dummy variable ($ALLY_{irt}$) on overlapping routes may be greater in magnitude than that on their non-overlapping ones. This will show that since the increased market power was found on routes that both alliance members served, it was due to the conversion of a former competitor to an ally, that is, through a decrease in the number of firms by one.

5.3 Method of Estimation

In Chapter 3 (section 3.10), the potential inconsistency of the pooled OLS parameter estimates due to the omitted variables problem had lead to the estimation of the price equation using first differencing (FD), a method under the class of models of unobserved heterogeneity. Thus, this will also be the method of estimation adopted in this chapter.

[116] Since the dominant effect found in Chapter 3 on the full sample was of increased market power, finding that the Alliance Participation dummy variable on non-overlapping routes was greater in magnitude than that on overlapping routes, translates into the dominance of the market power effect on the former.

Recall from Chapter 3 (section 3.9) that in term of our price equation (equation 5.1), the basic model of unobserved heterogeneity in which unobserved (route and firm) effects are explicitly included is:

$$\ln P_{irt} = X_{irt}\,\beta + U_{irt} + C_{ir} \tag{5.2}$$

First differencing (FD) lags the elements of the dependent and independent variables and subtracts them. If two quarters are considered, that is t = 2, then

$$\Delta \ln P_{irt} = \theta_2 + \Delta X_{irt}\,\beta + \Delta U_{irt} \tag{5.3}$$

where $\Delta \ln P_{irt} = \ln P_{irt} - \ln P_{ir,t-1}$ and θ_2 is the second period intercept.

5.4 Sub-Sample Evidence: First Difference Estimates of the Impact of Alliance Formation on Fares

Variable definitions are the same as were noted earlier in Table 3.2. Variable summary statistics by route sub-sample form Appendix G. This appendix shows that for instance, for the time period corresponding to the event, the average fare of the Delta-United alliance on their on overlapping routes was \$213.94, while that on their non-overlapping routes was \$198.09. For this alliance, the average trip distance was 1585.91 on their overlapping routes, and 1098.02 miles on their non-overlapping routes.

Table 5.1 shows the estimation results after the FD transformation and when the total sample is divided between alliance overlapping and non-overlapping routes. It shows that the sign of the Alliance Participation dummy variable ($ALLY_{irt}$) consistently

Table 5.1: First Difference Estimates of log (fare $_{irt}$),[a] for Route Sub-Samples.[b]

Dependent Variable: log (fare $_{irt}$)	ALLY $_{irt}$	D2	D3	Constant	R^2	N
Delta-United:						
Full Effect						
Ovelapping Routes	0.1377*	0.0455	0.0054	0.0382	0.0128	3,015
	(0.0266)	(0.0387)	(0.0353)	(0.0273)		
Non-Overlapping Routes	0.1058	0.0729	0.0304	0.0256	0.0080	15,642
	(0.0168)	(0.0194)	(0.0203)	(0.0135)		
Announcement Effect						
Ovelapping Routes	0.1351*	0.0571	-	0.0263	0.0084	2,016
	(0.0391)	(0.0393)		(0.0267)		
Non-Overlapping Routes	0.1522*	0.0875*	-	0.0200	0.0126	10,422
	(0.0233)	(0.0197)		(0.0135)		
Completion Effect						
Ovelapping Routes	0.1391*	-	-0.0293	0.0733	0.0121	2,016
	(0.0363)		(0.0358)	(0.0273)		
Non-Overlapping Routes	0.0599*	-	-0.0240	0.0703	0.0026	10,422
	(0.0238)		(0.0211)	(0.0135)		
Northwest-Continental:						
Full Effect						
Ovelapping Routes	0.1842	0.0159	-0.1373	0.0543	0.0344	417
	(0.1660)	(0.1361)	(0.1291)	(0.0783)		
Non-Overlapping Routes	0.0466*	-0.0133	0.0027	0.03700	0.0015	12,435
	(0.0186)	(0.0229)	(0.0237)	(0.0152)		
Announcement Effect						
Ovelapping Routes	0.1349	0.0028	-	0.0740	0.0397	279
	(0.1612)	(0.1368)		(0.0800)		

Table 5.1: First Difference Estimates of log ($fare_{irt}$),[a] for Route Sub-Samples.[b]

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	Constant	R^2	N
Delta-United:						
Full Effect						
Ovelapping Routes	0.1377*	0.0455	0.0054	0.0382	0.0128	3,015
	(0.0266)	(0.0387)	(0.0353)	(0.0273)		
Non-Overlapping Routes	0.1058	0.0729	0.0304	0.0256	0.0080	15,642
	(0.0168)	(0.0194)	(0.0203)	(0.0135)		
Announcement Effect						
Ovelapping Routes	0.1351*	0.0571	-	0.0263	0.0084	2,016
	(0.0391)	(0.0393)		(0.0267)		
Non-Overlapping Routes	0.1522*	0.0875*	-	0.0200	0.0126	10,422
	(0.0233)	(0.0197)		(0.0135)		
Completion Effect						
Ovelapping Routes	0.1391*	-	-0.0293	0.0733	0.0121	2,016
	(0.0363)		(0.0358)	(0.0273)		
Non-Overlapping Routes	0.0599*	-	-0.0240	0.0703	0.0026	10,422
	(0.0238)		(0.0211)	(0.0135)		
Northwest-Continental:						
Full Effect						
Ovelapping Routes	0.1842	0.0159	-0.1373	0.0543	0.0344	417
	(0.1660)	(0.1361)	(0.1291)	(0.0783)		
Non-Overlapping Routes	0.0466*	-0.0133	0.0027	0.03700	0.0015	12,435
	(0.0186)	(0.0229)	(0.0237)	(0.0152)		
Announcement Effect						
Ovelapping Routes	0.1349	0.0028	-	0.0740	0.0397	279
	(0.1612)	(0.1368)		(0.0800)		

indicated the dominance of the increased market power effect from the formation of each of the three alliances on *both* route sub-samples.

Comparing sub-sample regression results in Table 5.1 with those for the full sample in Table 3.4 shows which sub-sample lead the increased market power results of Chapter 3 and that were noted in Table 3.4 for each of the three domestic alliances. For instance, for the US Airways-American alliance and for its full effect, the market power result of Chapter 3 was lead by the growth in the price gap on routes that were *not* jointly served by both US Airways and American Airlines. For Delta-United, evidence of the realization of increased market power that was noted earlier in Table 3.4, is now seen through the division of the full route sample into sub-samples, to have been driven by the growth in the price gap on routes that both Delta Airlines and United Airlines served.

Next, in examining the sub-sample results in terms of the timing of fare changes, Table 5.1 shows that for the Delta-United alliance, it was in the announcement period and on their non-overlapping routes that the alliance participation had a stronger impact on the growth in the price gap. Specifically, the announcement of the Delta-United alliance was associated with a 15% increase in the price gap. This quantifies the advantage created just by alliance announcement for its member firms, due to this new 'firm' now seeming to operate at a larger size, or through multi-market contact. In the post alliance formation period though, the parameter estimate of the Alliance Participation dummy variable ($ALLY_{irt}$) showed a stronger impact on the growth in the price gap on routes that both member carriers did jointly serve. Overall, this effect dominated and allows the conclusion that the market power derived by the Delta-United alliance after alliance announcement and a year into full fledged operations, was due to an increase in concentration on these busy routes, that is, through the reduction in the number of rivals by one.

Table 5.1 shows that for the US Airways-American alliance, the member firms were also able to exercise greater market power even during alliance discussions and on routes that both did not jointly serve. Specifically, immediately after the announcement of the US Airways-American alliance, the price gap between alliance participants and their major rivals grew by 22%. This result can be explained by the advantages created for the firm now (seeming to) operate at a larger size, or through the workings of multi-market contact.

The overall results for the Northwest-Continental alliance are qualitatively similar to those noted above for the US Airways-American alliance. Specifically, the dominance of the increased market power effect shown earlier in Table 3.4 was lead by the growth in the price gap on routes that both member carriers did *not* jointly serve. A notable difference was seen between this and the US Airways-American alliance in terms of the timing of the fare changes. Results in Table 5.1 show that during the announcement effect period, the growth in the price gap due to the announcement of this alliance was not statistically significant: alliance announcement was not a significant source of any growth in the price gap. Recall from Chapter 1 (section 1.4) that this alliance was the first to be announced and that the generous degree of integration planned between Northwest Airlines and Continental Airlines had attracted concern by both regulators and journalists alike. Table 5.1 shows that it was only after the alliance began operations that there was an increase in the price gap. Parameter estimates of the Alliance Participation dummy variable ($ALLY_{irt}$) during the completion effect show that the completion of this alliance increased the price gap by 7%.

That a dominant market power effect can take place even on routes that partner carriers do not jointly serve is especially interesting since in the past, the permissibility of these alliances has been judged by regulators on the basis of the degree of overlap between the carriers.[117] In this context, Table 5.1 reveals that the Delta-United and US Airways-American alliances, the first two to begin operations, exercised their increased market power even during alliance discussions on routes on which they did not both serve.

Next, Appendix H shows pooled OLS estimation results of the fare impact ($lfare_{irt}$) from alliance participation ($ALLY_{irt}$) on these route sub-samples. Pooled OLS estimation allows us to examine the relation between alliance participation and fare changes after controlling for the scarcity of two important (time invariant) inputs, that is the scarcity of gates/slots ($Gate/Slot_r$) and the absence of a competitor airport in the same metropolitan area ($ARPT_r$).[118] Estimation results in this appendix show the robustness of our route sample-specific conclusions to the method of estimation: the Alliance Participation dummy variable ($ALLY_{irt}$) retains its positive sign and dominant effect on the same route sub-sample as was noted earlier in Table 5.1.[119]

Note also that in Appendix H, the parameter estimate for the airport isolation variable ($ARPT_r$) variable was negative for the Delta-United and US Airways-American alliances, showing that the absence of another airport nearby *prevented* these alliances from segmenting demand by elasticity, a result dominant on their overlapping routes.

A comparison of the parameter estimates in Table 5.1 with those in Appendix H shows that they are generally quantitatively comparable and qualitatively similar. Thus

[117] See for instance, U.S. General Accounting Office RCED-99-37.
[118] See Table 3.2 for definitions of explanatory variables.

results show robustness to the method of estimation and the overall message is the same: participation in one of the major domestic alliances allowed members with a fare growth greater than those of firms remaining outside these agreements. Even on the route sub-sample on which there was a large potential for the realization of cost efficiencies (that is, on alliance overlapping routes) there is no evidence that such an effect was ever realized.

FD-Two Stage Least Squares estimates of the impact on the growth in airport dominance on these sub-samples due to alliance formation, are shown in Appendix I.

5.5 Synopsis and Conclusion

This chapter began with the hypothesis that in examining the direction of the growth in price gap of the firms participating in one of the three major domestic alliances, if on the one hand greater market power dominance was noted on their overlapping routes, then this will show that market power was lead by a change in the availability of travel options. That is, due to the conversion of a former competitor to an ally or a decrease in the number of firms.

On the other hand, evidence of a dominant growth in the price gap on alliance non-overlapping routes suggests that demand complementarities (or multi-market contact) between alliance forming carriers were more important. That is, that the market power noted earlier in Chapter 3 was derived from the advantages accruing to a firm now operating at a larger size.

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[119] Except for the announcement effect for Delta-United in which pooled OLS estimation shows a dominant alliance effect on alliance overlapping routes.

Results shown in this chapter indicate strong evidence in support of the market power hypothesis on *both* sub-samples and for *all* three alliances.[120] Even on routes where there was the greatest potential for the realization of cost synergies that is, on overlapping routes, neither of the three alliances exhibited its realization at any period from before alliance announcement to a year into its operations. In fact, an overall dominant growth in the price gap on overlapping routes for the Delta-United and Northwest-Continental showed that their increased market power was derived from a reduction in the travel options available to travelers. While for the US Airways-American alliance, overall, demand complementarities or multi-market contact were more important for the realization of increased market power.

[120] Recall that the Department of Transportation has previously approved airline alliances on the grounds that the allying carriers serve largely non-overlapping and therefore unrelated markets.

Chapter 6. Summary and Conclusions

This paper primarily investigated (within the general framework of Bresnahan, 1989) the price behavior of the three major domestic airline alliances that were announced in early 1998, causing pairings among the six most dominant carriers in the U.S. airline industry. The primary hypothesis examined was whether these agreements had resulted in improvements in efficiency or in the realization of increased market power.

In Chapter 1, some of the structural and partnership differences between international and domestic airline alliances were highlighted. These differences would be the basis for understanding the empirical results of previous research examining international alliances in the post deregulation airline industry. For instance, in Chapter 2 it was discussed that consumer benefits are realizable from code-sharing between international carriers since their itineraries generally have an interline feature. Also, international alliance member networks are more complementary in nature and some post-alliance network realignment may have eliminated redundant routes among the partners.[121] This discussion formed the basis for understanding the distinctly different results when examining domestic airline alliances.

Chapter 1 also discussed that the major domestic alliances were announced at a time when many of the industry's major players were both struggling financially and competing aggressively with other domestic carriers.[122] This dichotomy is an important

[121] The Northwest-KLM international alliance, formed in 1991, had this feature with Northwest abandoning some European routes and adding some routes from non-hub American cities to Amsterdam.

[122] Anti-competitive concerns continue to be part of the analysis of this industry, as major carriers are inclined to exert discipline when threatened with rival entry. For instance, in May 1999 and under Section 2 of the Sherman Act, the Department of Justice sued American Airlines from attempting to monopolize through predation, service to and from its Dallas-Fort Worth airport.

aspect of the industry. A number of empirical studies on the domestic airline industry reviewed in Chapter 2, provided evidence of the increased market power that had already resulted from carrier mergers or though high airport dominance, and the financial difficulties of the industry were only exacerbated in late 2001 when it became obvious that this cyclical industry suffered not only from cost inefficiencies but was also now vulnerable to a set of international political motivations.

Regression results in Chapter 3 and Chapter 4 provided a quantification of the anticompetitive impact of domestic alliance formation that had taken place in this environment. Our results provide strong and consistent evidence that increased market power dominated each domestic alliance event. Specifically, the parameter estimate of the Alliance Participation dummy variable ranged from 4% for the Northwest-Continental alliance to 22% for the US Airways-American alliance, results that were statistically significant at the 1% level and that provide evidence that each domestic alliance had resulted in the increase in the price gap between alliance carriers and their major rivals. Results from an alternative method of estimation were qualitatively similar. The public policy implications of these results are in general against the permissibility of cooperative arrangements between two firms that were once each other's biggest rivals, and in particular, against the recent trend of domestic alliance formation that has created an *additional* layer of legitimate anti-trust and regulatory concern.

Next, given that previous literature on the airline industry has established the strong positive association between airport dominance and fares, a quantification of the association between the alliance event and the change in airport dominance was sought. This formed Chapter 4 and there, alternative methods of estimation again provided qualitatively similar and quantitatively strong results. These results were shown in Table

4.5 where due to the persistent endogeneity of an explanatory variable, the first difference-2SLS estimation method was employed. Parameter estimates ranged from 14% for the Northwest-Continental alliance to 47% for the US Airways-American alliance, providing evidence that alliance formation caused a strong growth in the airport dominance gap between alliance participants and the firms remaining outside these agreements.

Then in Chapter 5 (Table 5.1), a dominant Alliance Participation dummy variable was noted for the Delta-United alliance on overlapping routes, indicating that its market power effect was lead by a change in the availability of travel options, that is, due to the conversion of a former competitor to an ally or due to a decrease in the number of firms. On the other hand, a dominant Alliance Participation dummy variable on non-overlapping routes shows that demand complementarities (or multi-market contact) between the carriers were important and that market power was derived from the advantages accruing to a firm now operating at a larger size. This result was found for the US Airways-American and Northwest-Continental alliances.

The results shown in this paper provide the answer to a question that has confounded regulators concerned with the anticompetitive impact from the increasing 'cooperation' in the industry.[123] While regulatory agencies have been in what seems like a constant state of inquiry of the industry's conduct, to the best of our knowledge there is no other detailed empirical research addressing this issue. An interesting extension of this work would be to examine the fare impact of domestic alliance formation on

[123] An interesting extension of this work would be to examine the fare impact of domestic alliance formation on different consumer 'types', that is, on leisure versus business travelers. To the extent that these alliances were formed to better retain the demand of this lucrative segment, this extension is an important one. The analysis could be also be extended to include a larger set of airports. Further, a clarification of why different sub-sample results were seen across the three domestic alliances is needed.

different consumer 'types', that is, on leisure versus business travelers. To the extent that these alliances were formed to better retain the demand of this lucrative segment, this extension is an important one. Further, a clarification of why differences in sub-samples results were found is also needed.

While the timing of their fare responses highlighted some differences between the individual alliances, the uniformity of the increased market power result supports the generalization of arguments against each of these arrangements. However, the results of this paper and the arguments raised in it need not be in conflict with those raised to improve the financial strength of the industry. Instead, these results not only underscore the need to enhance and preserve competition in this industry, but also for sustaining and extending conditions that force improvements in firm level efficiency. While partnerships do reduce actual and potential competition by their very nature, it is important that they also create additional efficiencies.[124] That is, cooperation need not be in conflict with the ideals of competition and firms should be permitted cooperation with competing firms if the aim and result is an improvement in consumer welfare. However, there is a need to distinguish between these measures and those that allow firms the power to achieve and exercise market power through various antitrust loopholes. The former refers to measures such as the airline financial stabilization package that rushed through Congress in the weeks following September 11, 2001 and the latter, to the recent

[124] See Kroszner, Mullin, Jaffe and Alexander (2002) for a discussion of various organizational forms with motivations and effects similar to those of outright mergers.

decision by the Department of Transportation to allow further 'consolidation' of this industry through even wider domestic alliances.[125]

[125] See Atlanta Journal-Constitution, "Delta to Network with Rivals. Carrier Expected to Joint Northwest, Continental Airlines" August 23, 2002. Also, The New York Times, "DOT Approves United-US Air Code-sharing', October 3, 2002.

APPENDICES

Appendix A: Data Base Construction.

A record in the Origin and Destination Survey (DB1A) is an observation with the carrier, time, origin and destination airport, itinerary and fare. A number of restrictions are applied to this large database. We consider only tickets representing trips outbound from the base airport. Additionally, the following standard screens are used to remove records from the database:

1. Records with non-credible fares that suggest reporting errors. This screen is based on yields for which mileage categories are the same as were used by the Civil Aeronautics Board and the General Accounting Office.
2. Open jaw tickets that are neither one-way, nor round trips.
3. Interline tickets, that is trips that involve travel on more than one carrier.
4. Non-coach fares, that is all business and first class tickets, except for Southwest, which reports all tickets as first class.
5. Zero fare tickets.
6. Tickets that are not direct or have more than one stop between the trip origin and destination.
7. Routes with at least one endpoint outside the continental United States.

Appendix B: The 45 Busiest Airports.

The following are the 45 busiest airports of the country, ranked by 1999 passenger enplanements.

1. Atlanta
2. Chicago- O Hare
3. Los Angeles
4. Dallas/Ft. Worth
5. San Francisco
6. Denver
7. Minneapolis
8. Detroit
9. Miami
10. Newark
11. Las Vegas
12. Phoenix
13. Houston
14. New York- JFK
15. St Louis
16. Orlando
17. Seattle
18. Boston
19. Philadelphia
20. New York-La Guardia

21. Cincinnati
22. Charlotte
23. Salt Lake City
24. Washington (Dulles)
25. Pittsburgh
26. Baltimore
27. Tampa
28. Washington (Ronald Reagan)
29. Fort Lauderdale
30. Portland
31. Chicago - Midway
32. Cleveland
33. San Jose
34. Memphis
35. Oakland
36. New Orleans
37. Raleigh
38. Houston
39. Nashville
40. Indianapolis
41. San Antonio
42. Dallas
43. Austin
44. Columbus

45. Albuquerque

Source: ACI Traffic Data: World airports ranking by total passengers (1999). http://www.airports.org/traffic/td_passengers

Appendix C: Gate Controlled and Slot Constrained Airports

Airport(Code)	Type of Constraint
1. Charlotte (CLT)	Gate
2. Chicago O'Hare (ORD)[126]	Slot
3. Cincinnati (CVG)	Gate
4. Detroit (DTW)	Gate
5. Minneapolis (MSP)	Gate
6. Newark (EWR)	Gate
7. New York (JFK)	Slot
8. New York (LaGuardia)	Slot
9. Pittsburgh (PIT)	Gate
10. Washington-Reagan (DCA)	Slot

Source: U.S. General Accounting Office, GAO/T-RCED-98-112.

[126] The High Density Rule was lifted at Chicago, O'Hare in July 2002.

Appendix D: Cities Served by More Than One Airport*

1. Chicago (O'Hare and Midway)
2. Dallas ((Ft. Worth and Love Field)
3. Detroit (Metro and City)
4. Houston (Bush and Hobby)
5. Los Angeles (Los Angeles International and Burbank)
6. Newark (JFK and LaGuardia)
7. New York (LaGuardia and Newark)
8. San Francisco (San Francisco International and Oakland)
9. San Jose (San Jose International and San Francisco)
10. Washington (Dulles and Baltimore)

* Secondary airport must fall within the top 45 busiest airports of the country to qualify consideration in our sample of routes.

Source: OAG Desktop Guide, June 1999.

Appendix E: Hub Specific [a] Pooled OLS Estimates of log (fare $_{irt}$).[b]

Dependent Variable: log (fare $_{irt}$)	ALLY $_{irt}$	D2	D3	lDIST $_r$	Gate/Slot $_r$ [b]	ARPT $_r$ [b]	Constant	R^2	N
A.Delta-United:									
Full Effect									
Atlanta (ATL)	0.1411*	-0.0336	-0.0598**	0.2646*	0.0266	-	3.2901	0.1287	2106
	(0.0293)	(0.0294)	(0.0292)	(0.0227)	(0.0287)		(0.1614)		
Cincinnati (CVG)	0.2041*	-0.0238	-0.0162	0.1382*	-	-	4.2573	0.0610	2106
	(0.0328)	(0.0389)	(0.0407)	(0.0227)			(0.1585)		
Denver (DEN)	0.1306*	-0.0574**	-0.0688**	0.1923*	-0.0239	0.1163	3.7777	0.0282	2106
	(0.0269)	(0.0293)	(0.0301)	(0.0366)	(0.0247)	(0.0920)	(0.2826)		
Dallas (DFW)	0.1248**	-0.0540**	-0.0294	0.4058*	0.0925*	0.0006	2.4491	0.1971	2079
	(0.0264)	(0.0268)	(0.0280)	(0.0263)	(0.0246)	(0.0252)	(0.1861)		
Dulles (IAD)	0.1267*	0.0153	-0.0300	0.2907*	0.1910*	-0.0011	3.1401	0.1472	1998
	(0.0400)	(0.0339)	(0.0361)	(0.0271)	(0.0494)	(0.0318)	(0.2041)		
Los Angeles (LAX)	0.0941*	0.0180	-0.0326	0.4993*	0.1221*	-0.1197*	1.5923	0.3562	2106
	(0.0238)	(0.0275)	(0.0264)	(0.0232)	(0.0255)	(0.0252)	(0.1750)		
Chicago (ORD)	0.0171	-0.0016	0.0377	0.1446*	-	-0.0675**	4.2421	0.0505	2052
	(0.0294)	(0.0338)	(0.0331)	(0.0219)		(0.0294)	(0.1553)		
San Francisco (SFO)	0.1303*	0.0317	-0.0584**	0.4523*	0.0752*	-0.0964*	1.9693	0.2286	1998
	(0.0348)	(0.0299)	(0.0248)	(0.0301)	(0.0250)	(0.0275)	(0.2288)		
Salt Lake City (SLC)	0.2249*	0.0589**	-0.0356	0.2313*	0.1326*	-	3.3414	0.1075	2106
	(0.0307	(0.0303)	(0.0284)	(0.0310)	(0.0272)		(0.2248)		
Announcement Effect									
Atlanta (ATL)	0.0955**	-0.0248	-	0.2696*	0.0484	-	3.2507	0.1261	1404
	(0.0411)	(0.0306)		(0.0281)	(0.0362)		(0.1991)		
Cincinnati (CVG)	0.1707*	-0.0148	-	0.1303*	-	-	4.2905	0.0497	1404
	(0.0460)	(0.0413)		(0.0275)			(0.1907)		

Appendix E (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	$lDIST_r$	$Gate/Slot_r$ [b]	$ARPT_r$ [b]	Constant	R^2	N
Denver (DEN)	0.1233*	-0.0561***	-	0.1901*	-0.0179	0.1289	3.7785	0.0271	1404
	(0.0340)	(0.0306)		(0.0411)	(0.0303)	(0.1211)	(0.3257)		
Dallas (DFW)	0.1198*	-0.0529	-	0.4159*	0.1008**	0.0145	2.3675	0.2050	1386
	(0.0372)	(0.0277)		(0.0319)	(0.0277)	(0.0301)	(0.2256)		
Dulles (IAD)	0.0811**	0.0218	-	0.2500*	0.1476*	-0.0415	3.4571	0.1365	1332
	(0.0423)	(0.0348)		(0.0300)	(0.0549)	(0.0350)	(0.2250)		
Los Angeles (LAX)	0.0476**	0.0245	-	0.4659*	0.1362*	-0.1092*	1.8261	0.3163	1404
	(0.0340)	(0.0284)		(0.0313)	(0.0329)	(0.0325)	(0.2356)		
Chicago (ORD)	0.0221	-0.0054	-	0.1074*	-	0.0466**	4.4773	0.0284	1368
	(0.0432)	(0.0353)		(0.0258)		(0.0366)	(0.1767)		
San Francisco (SFO)	0.0670***	0.0394	-	0.4071*	0.0855*	-0.0652**	2.8227	0.1872	1332
	(0.0445)	(0.0310)		(0.0385)	(0.0334)	(0.0357)	(0.2934)		
Salt Lake City (SLC)	0.1919*	0.0615**	-	0.1887	0.1147***	-	3.6535	0.0769	1404
	(0.0462)	(0.0318)		(0.0362)	(0.0318)		(0.2627)		
Completion Effect									
Atlanta (ATL)	0.1956*	-	-0.0646**	0.3033*	0.0225*	-	3.0215	0.1652	1404
	(0.0407)		(0.0305)	(0.0267)	(0.0343)		(0.1849)		
Cincinnati (CVG)	0.2493*	-	-0.0577***	0.1911*	-	-	3.9139	0.0984	1404
	(0.0464)		(0.0430)	(0.0266)			(0.1821)		
Denver (DEN)	0.1368*	-	-0.0354	0.1695*	0.0144	-0.0017	4.008	0.0217	1404
	(0.0419)		(0.0325)	(0.0465)	(0.0306)	(0.0999)	(0.3483)		
Dallas (DFW)	0.1265*	-	0.0025	0.3668*	0.0922*	-0.0082	2.6906	0.1815	1386
	(0.0830)		(0.0275)	(0.0317)	(0.0297)	(0.0292)	(0.2238)		
Dulles (IAD)	0.1639**	-	-0.0770**	0.2666*	0.2016*	-0.0173	3.3569	0.1268	1332
	(0.0684)		(0.0383)	(0.0333)	(0.0595)	(0.0401)	(0.2468)		

Appendix E (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	$lDIST_r$	$Gate/Slot_r$[b]	$ARPT_r$[b]	Constant	R^2	N
Los Angeles (LAX)	0.1345*	-	-0.0711*	0.4862*	0.0830*	-0.1355*	1.7847	0.3600	1404
	(0.0342)		(0.0258)	(0.0254)	(0.0280)	(0.0283)	(0.1921)		
Chicago (ORD)	0.0051	-	-0.0347	0.1255*	-	-0.0310	4.3441	0.0360	1368
	(0.0411)		(0.0358)	(0.0264)		(0.0361)	(0.1841)		
San Francisco (SFO)	0.1784*	-	-0.1146	0.3866	0.0592***	-0.0793**	2.5025	0.1776	1332
	(0.0557)		(0.0285)	(0.0367)	(0.0318)	(0.0342)	(0.2769)		
Salt Lake City (SLC)	0.2571*	-	-0.1433*	0.2233*	0.1039*	-	3.5080	0.0963	1404
	(0.0420)		(0.0314)	(0.0363)	(0.0342)		(0.2551)		
B. Northwest-Continental:									
Full Effect									
Cleveland (CLE)	0.0254	0.0476**	-0.0101	0.1627	-	-0.0656**	3.9987	0.0737	2133
	(0.0329)	(0.0292)	(0.0287)	(0.0203)		(0.0267)	(0.1477)		
Detroit (DTW)	0.0531**	-0.0066	-0.1412*	0.1688*	-	-	4.2265	0.0505	2160
	(0.0287)	(0.0267)	(0.0267)	(0.0314)			(0.2185)		
Houston (IAH)	-0.0627**	0.0450**	-0.0049	0.2294	0.0177	-	3.8301	0.0828	2160
	(0.0317)	(0.0300)	(0.0318)	(0.0242)	(0.0297)		(0.1686)		
Memphis (MEM)	0.0468**	0.0025	-0.1602*	0.4529*	0.2448*	0.0633**	2.1046	0.2528	2133
	(0.0323)	(0.0313)	(0.0308)	(0.0297)	(0.0284)	(0.0202)	(0.2134)		
Minneapolis (MSP)	0.1260*	-0.0141	-0.0435***	0.2437*	0.2449*	-	3.4063	0.1135	2187
	(0.0346)	(0.0295)	(0.0296)	(0.0231)	(0.0409)		(0.1648)		
Newark (EWR)	-0.0291	-0.0146	-0.0713	0.2006	-	-0.0685**	4.0460	0.1223	2079
	(0.0295)	(0.0302)	(0.0315)	(0.0208)		(0.0286)	(0.1545)		
Announcement Effect									
Cleveland (CLE)	-0.0302	0.0571	-	0.1563*	-	0.0669**	4.0427	0.0719	1422
	(0.0453)	(0.0303)		(0.0254)		(0.0324)	(0.1817)		

Appendix E (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	$lDIST_r$	Gate/Slot$_r$ [b]	$ARPT_r$ [b]	Constant	R^2	N
Detroit (DTW)	-0.0285	0.0076	-	0.1142*	-	-	4.6010	0.0132	1440
	(0.0380)	(0.0276)		(0.0382)			(0.2653)		
Houston (IAH)	-0.1095**	0.0552**	-	0.2453*	0.0295	-	3.7207	0.0984	1440
	(0.0442)	(0.0311)		(0.0296)	(0.0354)		(0.2053)		
Memphis (MEM)	0.0298	0.0066	-	0.4865*	0.3062*	0.0790**	1.8455	0.2935	1422
	(0.0504)	(0.0326)		(0.0340)	(0.0342)	(0.0340)	(0.2435)		
Minneapolis (MSP)	0.0675**	-0.0031	-	0.2067*	0.2475*	-	3.6541	0.0856	1458
	(0.0458)	(0.0304)		(0.0276)	(0.0470)		(0.1959)		
Newark (EWR)	-0.0340	-0.0157	-	0.2272*	-	-0.0350	3.8383	0.1503	1386
	(0.0419)	(0.0317)		(0.0267)		(0.0337)	(0.1977)		
Completion Effect									
Cleveland (CLE)	0.0838**	-	-0.0721**	0.1755*	-	-0.0605	3.9605	0.0800	1422
	(0.0468)		(0.0310)	(0.0234)		(0.0343)	(0.1692)		
Detroit (DTW)	0.1359*	-	-0.1584*	0.1923*	-	-	4.0677	0.0661	1440
	(0.0413)		(0.0279)	(0.0375)			(0.2608)		
Houston (IAH)	-0.0135	-	-0.0472***	0.2202*	0.0148	-	3.9234	0.0746	1440
	(0.0454)		(0.0329)	(0.0291)	(0.0367)		(0.2032)		
Memphis (MEM)	0.0616**	-	-0.1730*	0.4101*	0.2099	0.0573**	2.4246	0.2144	1422
	(0.0396)		(0.0319)	(0.0377)	(0.0349)	(0.0345)	(0.2707)		
Minneapolis (MSP)	0.1778*	-	-0.0602**	0.2407*	0.2397*	-	3.4344	0.1098	1458
	(0.0509)		(0.0318)	(0.0285)	(0.0572)		(0.2006)		
Newark (EWR)	-0.0210	-	-0.0532***	0.1724*	-	-0.-838**	4.2340	0.0949	1386
	(0.0412)		(0.0335)	(0.0254)		(0.0366)	(0.1930)		

Appendix E (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	$lDIST_r$	$Gate/Slot_r$ [b]	$ARPT_r$ [b]	Constant	R^2	N
C. US Airways-American:									
Full Effect									
Charlotte (CLT)	0.1020*	-0.1192*	-0.1521*	0.0149	-	-	5.4573	0.0215	2533
	(0.0364)	(0.0360)	(0.0403)	(0.0149)			(0.0433)		
Dallas (DFW)	0.1186*	-0.1136*	-0.1041*	0.0251**	0.1492*	-0.0421**	5.2821	0.0424	2506
	(0.0401)	(0.0312)	(0.0306)	(0.0140)	(0.0260)	(0.0285)	(0.0438)		
Miami (MIA)	0.0516**	-0.0484**	-0.0926*	0.0187***	-0.0709*	-	5.1650	0.0172	2425
	(0.0289)	(0.0270)	(0.0275)	(0.0133)	(0.0276)		(0.0347)		
Chicago (ORD)	0.1638***	-0.2412*	-0.2992*	0.1948*	-	-	5.0002	0.5003	295
	(0.1156)	(0.0763)	(0.1096)	(0.0335)			(0.0811)		
Philadelphia (PHL)	0.0780**	-0.1401*	-0.1518*	0.0665*	-0.1272*	-	5.3223	0.0532	2452
	(0.0365)	(0.0315)	(0.0312)	(0.0137)	(0.0840)		(0.0360)		
Pittsburgh (PIT)	0.1054*	-0.1896*	-0.1932*	0.0535*	-	-	5.3413	0.0529	2452
	(0.0344)	(0.0344)	(0.0361)	(0.0141)			(0.0380)		
Announcement Effect									
Charlotte (CLT)	-0.0214	-0.0931**	-	0.0441*	-	-	5.3956	0.0202	1692
	(0.0593)	(0.0380)		(0.0178)			(0.0497)		
Dallas (DFW)	0.0958***	-0.1103*	-	0.0285**	0.1687*	-0.0376	5.2677	0.0424	1674
	(0.0633)	(0.0323)		(0.0177)	(0.0330)	(0.0368)	(0.0523)		
Miami (MIA)	0.0065	-0.0412***	-	0.0240***	-0.0766**	-	5.1555	0.0112	1620
	(0.0443)	(0.0287)		(0.0177)	(0.0341)		(0.0427)		
Chicago (ORD)	0.0181	-0.2170*	-	0.1948*	-	-	5.0027	0.6354	198
	(0.0861)	(0.0788)		(0.0350)			(0.0841)		
Philadelphia (PHL)	-0.0245	-0.1297*	-	0.0780*	-0.1034*	-	5.2959	0.0489	1638
	(0.0536)	(0.0325)		(0.0177)	(0.0429)		(0.0423)		

Appendix E (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	D2	D3	$lDIST_r$	$Gate/Slot_r$ [b]	$ARPT_r$ [b]	Constant	R^2	N
Pittsburgh (PIT)	0.0567	-0.1802*	-	0.0597*	-	-	5.3290	0.0525	1638
	(0.0485)	(0.0360)		(0.0164)			(0.0417)		
Completion Effect									
Charlotte (CLT)	0.1836*	-	-0.0719***	0.0169	-	-	5.3551	0.0149	1692
	(0.0459)		(0.0404)	(0.0187)			(0.0476)		
Dallas (DFW)	0.1328*	-	-0.0090	0.0439*	0.1208*	-0.0168	5.1390	0.0328	1674
	(0.0515)		(0.0285)	(0.0160)	(0.0299)	(0.0328)	(0.0436)		
Miami (MIA)	0.0896**	-	-0.0592**	0.0166	-0.0409	-	5.1230	0.0106	1620
	(0.0386)		(0.0290)	(0.0156)	(0.0345)		(0.0409)		
Chicago (ORD)	0.2893**	-	-0.0950	0.2296*	-	-	4.7180	0.4373	198
	(0.1705)		(0.1199)	(0.0422)			(0.1154)		
Philadelphia (PHL)	0.1593*	-	-0.0331	0.0699*	-0.1086*	-	5.1793	0.0379	1638
	(0.0488)		(0.0310)	(0.0159)	(0.0398)		(0.0389)		
Pittsburgh (PIT)	0.1236*	-	-0.0265	0.0760*	-	-	5.1259	0.0366	1638
	(0.0465)		(0.0364)	(0.0172)			(0.0447)		

(a) With heteroskedasticity robust standard errors.

(b) See Appendix C for list of gate and airport constrianed airports within our sample and Appendix D for airports that are not geographically 'isolated'.

See Table 3.2 for dependent and explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

Appendix F: Pooled OLS Estimates[a] of log (AM_{irt}), Route Market Share Excluded.[b]

Dependent Variable: log (AM_{irt})	Network:	$ALLY_{irt}$	D2	D3	$Gate/Slot_r$	$ARPT_r$	Constant	R^2	N
Full Effect	DL-UA	1.7143*	-0.2681*	0.0643*	-0.0853*	-0.0108	1.8986	0.1893	18,657
		(0.0146)	(0.0208)	(0.0187)	(0.0168)	(0.0223)	(0.0268)		
	NW-CO	1.6507*	-0.1880*	-0.1884	-0.0185	0.0600**	2.0918	0.2100	12,852
		(0.0124)	(0.0215)	(0.0212)	(0.0169)	(0.0228)	(0.0280)		
	US-AA	1.7969*	-0.2205*	-0.1685	-0.0710*	0.0482***	2.0744	0.2140	12,663
		(0.0150)	(0.0239)	(0.2380)	(0.0182)	(0.0330)	(0.0368)		
Announcement Effect									
	DL-UA	1.4570*	-0.2320*	-	-0.0691*	-0.0172	1.8978	0.1009	11,826
		(0.0197)	(0.0215)		(0.0219)	(0.0289)	(0.0308)		
	NW-CO	1.6407*	-0.1868	-	0.0133	0.0529**	2.0947	0.1534	8568
		(0.0174)	(0.0221)		(0.0216)	(0.0293)	(0.0335)		
	US-AA	1.8567*	-0.2282*	-	-0.0648*	0.0607**	2.0595	0.1661	8442
		(0.0211)	(0.0245)		(0.0232)	(0.0415)	(0.0443)		
Completion Effect									
	DL-UA	1.9701*	-	-0.0681*	-0.1078*	-0.0041	1.8735	0.2029	11,826
		(0.0181)		(0.0199)	(0.0203)	(0.0268)	(0.0286)		
	NW-CO	1.6608*	-	-0.2108*	-0.0118	0.0626**	2.1067	0.1614	8568
		(0.0178)		(0.0217)	(0.0212)	(0.0286)	(0.0332)		
	US-AA	1.7371*	-	-0.1727*	-0.0580**	0.0507	2.0763	0.1557	8442
		(0.0212)		(0.0240)	(0.0228)	(0.0410)	(0.0436)		

(a) With heteroskedasticity robust standard errors.

(b) See Table 4.1 for explanatory variable definitions. See Chapter 3, Section 3.7 for a description of the timing of fare changes.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

Appendix G: Variable Descriptive Statistics by Sub-Sample.[a]

Variable	Route Sub-sample	Network	Mean	s.e.	Min.	Max.
Full Effect						
$Fare_{irt}$	Overlapping	DL-UA	213.94	128.71	18	1757
		NW-CO	199.48	102.65	24	982
		US-AA	210.44	110.59	55	1437
	Non-Overlapping	DL-UA	198.09	120.58	16	1710
		NW-CO	213.08	126.73	19	2591
		US-AA	217.95	119.06	15	1797
AM_{irt} (%)	Overlapping	DL-UA	11.86	14.59	0.2	77.6
		NW-CO	13.74	13.20	0.8	67.3
		US-AA	15.03	17.88	0.5	76.8
	Non-Overlapping	DL-UA	12.38	14.93	0.1	88.6
		NW-CO	13.52	13.55	0.2	88.6
		US-AA	14.33	15.84	0.2	96.7
MS_{irt} (%)	Overlapping	DL-UA	17.08	23.45	0.0	100
		NW-CO	19.52	30.16	0.1	100
		US-AA	16.88	28.73	0	98.7
	Non-Overlapping	DL-UA	20.03	28.26	0	100
		NW-CO	19.10	27.47	0.1	100
		US-AA	19.63	27.18	0.1	100
$DIST_r$	Overlapping	DL-UA	1585.91	617.58	228	2583
		NW-CO	1026.82	599.95	81	2565
		US-AA	1094.14	405.68	541	2243
	Non-Overlapping	DL-UA	1098.02	654.54	30	2704
		NW-CO	989.02	587.84	17	2565
		US-AA	1019.23	661.80	67	2724
$lagMS_{irt}$ (%)	Overlapping	DL-UA	16.87	23.69	0	100
		NW-CO	12.89	24.69	0	99.9
		US-AA	10.23	22.97	0	92.6
	Non-Overlapping	DL-UA	19.59	27.81	0.1	100
		NW-CO	12.86	24.3	0	100
		US-AA	12.34	22.99	0	100
Announcement Effect						
$Fare_{irt}$	Overlapping	DL-UA	219.54	138.96	17	1757
		NW-CO	203.08	105.00	24	982
		US-AA	216.19	123.55	55	1437

Appendix G (cont'd).

Variable	Route Sub-sample	Network	Mean	s.e.	Min.	Max.
Fare $_{irt}$	Non-Overlapping	DL-UA	198.65	118.11	17	1390
		NW-CO	218.01	131.18	19	2591
		US-AA	222.76	122.46	16	1797
AM $_{irt}$ (%)	Overlapping	DL-UA	11.12	13.55	0.3	77.6
		NW-CO	13.75	13.52	0.8	67.3
		US-AA	14.19	17.62	1.7	76.8
	Non-Overlapping	DL-UA	11.78	14.48	0.2	85.5
		NW-CO	13.55	13.54	0.4	83.1
		US-AA	14.31	16.07	0.4	84.1
MS $_{irt}$ (%)	Overlapping	DL-UA	17.19	23.88	0.1	100
		NW-CO	18.93	29.77	0.1	98
		US-AA	16.30	28.56	0.1	98.7
	Non-Overlapping	DL-UA	19.97	28.29	0.1	100
		NW-CO	19.08	27.52	0.1	100
		US-AA	19.69	27.35	0.1	100
DIST$_r$	Overlapping	DL-UA	1596.83	623.39	228	2583
		NW-CO	1026.07	619.25	105	2565
		US-AA	1091.82	377.95	541	1917
	Non-Overlapping	DL-UA	1101.10	651.94	67	2704
		NW-CO	988.84	587.31	17	2565
		US-AA	1019.50	661.72	67	2724
lagMS $_{irt}$ (%)	Overlapping	DL-UA	16.89	23.65	0.1	100
		NW-CO	13.63	25.16	0.1	97.7
		US-AA	12.72	26.13	0	92.6
	Non-Overlapping	DL-UA	19.34	27.4	0	100
		NW-CO	13.96	24.86	0	100
		US-AA	14.25	24.94	0	100
Completion Effect						
Fare $_{irt}$	Overlapping	DL-UA	212.15	128.01	15	1757
		NW-CO	201.81	110.33	24	982
		US-AA	209.68	121.72	57	1437
	Non-Overlapping	DL-UA	197.41	121.05	18	1710
		NW-CO	210.76	121.62	19	1710
		US-AA	210.21	114.49	15	1797
AM $_{irt}$ (%)	Overlapping	DL-UA	11.86	14.11	0.2	75.7
		NW-CO	13.4	12.96	1.3	67.3
		US-AA	15.33	18.44	0.5	76.8

Appendix G (cont'd).

Variable	Route Sub-sample	Network	Mean	s.e.	Min.	Max.
AM_{irt} (%)	Non-Overlapping	DL-UA	12.35	14.79	0.1	88.6
		NW-CO	13.52	13.44	0.2	88.6
		US-AA	14.26	15.52	0.2	96.7
MS_{irt} (%)	Overlapping	DL-UA	17.04	23.27	0.1	100
		NW-CO	20.6	30.97	0.1	100
		US-AA	16.79	29	0.1	98.7
	Non-Overlapping	DL-UA	20.03	28.4	0.1	100
		NW-CO	19.31	27.63	0.1	100
		US-AA	19.59	26.99	0.1	100
$DIST_r$	Overlapping	DL-UA	1571.7	612.45	264	2583
		NW-CO	1015.75	588.79	81	2554
		US-AA	1074.18	411.41	541	2243
	Non-Overlapping	DL-UA	1094.31	656.24	30	2704
		NW-CO	989.76	588.14	17	2565
		US-AA	1019.68	662.5	67	2724
$lagMS_{irt}$ (%)	Overlapping	DL-UA	17.06	23.58	0.1	100
		NW-CO	11.38	23.09	0.1	99.9
		US-AA	8.42	21.1	0	92.6
	Non-Overlapping	DL-UA	20.05	28.38	0.1	100
		NW-CO	11.1	23.09	0	100
		US-AA	9.94	20.7	0	100

(a) See Chapter 3, Section 3.7 for time period description and Table 4.1 for variable definitions.

Appendix H: Pooled OLS Estimates of log ($fare_{irt}$),[a] for Route Sub-Samples.[b]

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	$Gate/Slot_r$	$ARPT_r$	$lDIST_r$	D2	D3	Constant	R^2	N
Delta-United:									
Full Effect									
Ovelapping Routes	0.1886*	0.0534**	-0.3477*	0.2454*	-0.0137	-0.0607*	3.7611	0.1506	3,015
	(0.0228)	(0.0215)	(0.0323)	(0.0215)	(0.0257)	(0.0223)	(0.1679)		
Non-Overlapping Routes	0.1228*	0.1115*	-0.0411*	0.2699*	-0.0077	-0.0419*	3.2787	0.1386	15,642
	(0.0124)	(0.0099)	(0.0136)	(0.0093)	(0.0121)	(0.0121)	(0.0709)		
Announcement Effect									
Ovelapping Routes	0.1534*	0.0314	-0.3588*	0.2614*	-0.0052	-	3.6591	0.1409	2,016
	(0.0331)	(0.0281)	(0.0376)	(0.0261)	(0.0269)		(0.2020)		
Non-Overlapping Routes	0.0912*	0.1096*	-0.0379*	0.2382*	-0.0032	-	3.4985	0.1143	10,422
	(0.0167)	(0.0121)	(0.0167)	(0.0109)	(0.0125)		(0.0830)		
Completion Effect									
Ovelapping Routes	0.2294*	0.0531**	-0.3464*	0.2415*	-	-0.0782*	3.7996	0.1450	2,016
	(0.0306)	(0.0215)	(0.0323)	(0.0214)		(0.0200)	(0.1661)		
Non-Overlapping Routes	0.1488*	0.1120*	-0.0407*	0.2682*	-	-0.0544*	3.2980	0.1368	10,422
	(0.0184)	(0.0099)	(0.0137)	(0.0092)		(0.0111)	(0.0697)		
Northwest-Continental:									
Full Effect									
Ovelapping Routes	0.0623	0.1558*	0.0642	0.2319*	0.0412	-0.0203	3.4573	0.1456	417
	(0.0857)	(0.0596)	(0.1131)	(0.0639)	(0.0749)	(0.0710)	(0.4626)		
Non-Overlapping Routes	0.0283**	0.0588*	-0.0049	0.2351*	-0.0002	-0.0753*	3.6262	0.1035	12,435
	(0.0142)	(0.0109)	(0.0163)	(0.0103)	(0.0133)	(0.0133)	(0.0781)		
Announcement Effect									
Ovelapping Routes	0.1180	0.1702*	0.1864***	0.3122*	0.0312	-	2.8011	0.2430	270
	(0.1351)	(0.0674)	(0.1295)	(0.0692)	(0.0779)		(0.5082)		

Appendix H (cont'd).

Dependent Variable: log ($fare_{irt}$)	$ALLY_{irt}$	$Gate/Slo_{tr}$	$ARPT_r$	$lDIST_r$	D2	D3	Constant	R^2	N
Non-Overlapping Routes	-0.0166	0.0743*	-0.0040	0.2310*	0.0080	-	3.6435	0.1012	8,280
	(0.0202)	(0.0134)	(0.0199)	(0.0127)	(0.0138)		(0.0953)		
Completion Effect									
Ovelapping Routes	0.0291	0.1524*	0.0630	0.2302*	-	-0.0382	3.4951	0.1419	270
	(0.1094)	(0.0597)	(0.1131)	(0.0642)		(0.0674)	(0.4692)		
Non-Overlapping Routes	0.0742*	0.0589*	-0.0049	0.2355*	-	-0.0861*	3.6258	0.1043	8,280
	(0.0196)	(0.0109)	(0.0163)	(0.0103)		(0.0123)	(0.0776)		
US Airways-American:									
Full Effect									
Ovelapping Routes	0.1635*	0.1806*	-0.0695*	0.3341*	-0.0332	-0.0993***	3.1405	0.1512	413
	(0.0572)	(0.0493)	(0.0806)	(0.0728)	(0.0664)	(0.0626)	(0.5213)		
Non-Overlapping Routes	0.1963*	0.0844*	0.0018	0.2454*	-0.1155*	-0.1392*	3.5966	0.1379	12,250
	(0.0146)	(0.0106)	(0.0171)	(0.0095)	(0.0132)	(0.0133)	(0.0715)		
Announcement Effect									
Ovelapping Routes	0.1636*	0.1372**	-	0.3488*	0.0602	-	2.6999	0.1313	270
	(0.0584)	(0.0590)		(0.0878)	(0.0572)		(0.6205)		
Non-Overlapping Routes	0.1929*	0.0811*	-0.0007	0.2262*	0.0235	-	3.5945	0.1261	8,172
	(0.0147)	(0.0125)	(0.0203)	(0.0113)	(0.0124)		(0.0845)		
Completion Effect									
Ovelapping Routes	0.1886*	0.1793*	-0.2728*	0.3324*	-	-0.0940**	3.1524	0.1474	270
	(0.0853)	(0.0483)	(0.0769)	(0.0720)		(0.0543)	(0.5153)		

Appendix H (cont'd).

Dependent Variable: log (fare $_{irt}$)	ALLY $_{irt}$	Gate/Slot $_{r}$	ARPT $_{r}$	lDIST $_{r}$	D2	D3	Constant	R^2	N
Non-Overlapping Routes	0.2257*	0.0850*	0.0038	0.2428*	-	-0.1048*	3.5726	0.1271	8,172
	(0.0201)	(0.0106)	(0.0173)	(0.0094)		(0.0120)	(0.0707)		

(a) With heteroskedasticity robust standard errors.

(b) See Table 4.1 for explanatory variable definitions. See Chapter 5, Section 5.2 for sub-sample description.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

Appendix I: First Difference-2SLS Estimates of log (AM_{irt})[a] for Route Sub-Samples.[b]

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
Delta-United:							
Full Effect							
Ovelapping Routes	0.2349**	0.0263*	0.1323**	0.0444	-0.0781	0.3715	3,015
	(0.0807)	(0.0013)	(0.0706)	(0.0612)	(0.0434)		
Non-Overlapping Routes	0.2876*	0.0224*	0.1767*	0.0774*	-0.1005	0.4378	15,642
	(0.0331)	(0.0004)	(0.0355)	(0.0325)			
Announcement Effect							
Ovelapping Routes	0.1230***	0.0264*	0.1090**	-	-0.0561	0.3712	2,016
	(0.0773)	(0.0013)	(0.0603)		(0.0305)		
Non-Overlapping Routes	0.2725*	0.0224*	0.1373*	-	-0.0641	0.4371	10,422
	(0.0315)	(0.0004)	(0.0307)		(0.0163)		
Completion Effect							
Ovelapping Routes	0.3316*	0.0209*	-	-0.0773	0.0425	0.3349	2,016
	(0.0982)	(0.0020)		(0.0639)	(0.0524)		
Non-Overlapping Routes	0.3118*	0.0200*	-	-0.0863*	0.0532	0.4009	10,422
	(0.0337)	(0.0006)		(0.0340)	(0.0277)		
Northwest-Continental:							
Full Effect							
Ovelapping Routes	0.1134	0.0245*	-0.3078	-0.4075***	0.2031	0.2863	417
	(0.4084)	(0.0056)	(0.3365)	(0.2528)	(0.1832)		
Non-Overlapping Routes	0.1750*	0.0216*	0.0049	-0.0188	-0.1256	0.3800	12,435
	(0.0425)	(0.0006)	(0.0445)	(0.0420)	(0.0305)		

Appendix I (cont'd).

Dependent Variable: log (AM_{irt})	$ALLY_{irt}$	MS_{irt}	D2	D3	Constant	R^2	N
Announcement Effect							
Ovelapping Routes	0.4053	0.0280*	-0.2823	-	0.237	0.3398	279
	(0.4718)	(0.0056)	(0.3393)		(0.1858)		
Non-Overlapping Routes	0.1362*	0.0215*	-0.0002	-	-0.1304	0.3656	8,280
	(0.0520)	(0.0006)	(0.0463)		(0.0312)		
Completion Effect							
Ovelapping Routes	-0.3394	0.0281**	-	-0.1208	-0.1238	0.1940	279
	(1.1385)	(0.0145)		(0.3492)	(0.2815)		
Non-Overlapping Routes	0.1478**	0.0233*	-	0.0077	-0.1411	0.3653	8,280
	(0.0606)	(0.0008)		(0.0457)	(0.0340)		
US Airways-American:							
Full Effect							
Ovelapping Routes	0.6174***	0.0237*	0.0697	-0.0984	-0.3963	0.5756	413
	(0.4593)	(0.0040)	(0.1886)	(0.2309)	(0.1550)		
Non-Overlapping Routes	0.6088*	0.0280*	0.1221*	0.0388	-0.3488	0.4678	12,250
	(0.0649)	(0.0006)	(0.0465)	(0.0529)	(0.0326)		
Announcement Effect							
Ovelapping Routes	0.6289***	0.0235*	0.0733	-	-0.4006	0.6993	279
	(0.4765)	(0.0043)	(0.1926)		(0.1605)		
Non-Overlapping Routes	0.6232*	0.0278*	0.1283*	-	-0.3532	0.5287	8,172
	(0.0674)	(0.0007)	(0.0471)		(0.0332)		

Appendix I (cont'd).

Dependent Variable: log (AM_{irt})	ALLY $_{irt}$	MS $_{irt}$	D2	D3	Constant	R^2	N
Completion Effect							
Ovelapping Routes	0.6008**	0.0288*	-	-0.0791	-0.3989	0.5069	270
	(0.4529)	(0.0029)		(0.2335)	(0.1572)		
Non-Overlapping Routes	0.3437***	0.0311*	-	0.0577	-0.3650	0.4236	8,172
	(0.2632)	(0.0009)		(0.0542)	(0.0436)		

(a) With heteroskedasticity robust standard errors.

(b) See Table 4.1 for dependent and independent variable definitions. See Chapter 5, Section 5.2 for sub-sample definition.

*,** and ***: Statistically significant at the 1%, 5% and 10% level, respectively (two-tailed t-test).

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