Strategic Airline Alliance: Modelling and Empirical Analysis

by

Jong-Hun Park

B.B.A., Korea University, 1988
M.Sc., Korea Advanced Institute of Science and Technology, 1990

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Faculty of Commerce and Business Administration
The University of British Columbia
2053 Main Mall
Vancouver, B.C., Canada
V6T 1Z2

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ABSTRACT

During the past years, major airlines have extended their service networks primarily via strategic alliances with other airlines. The purpose of this thesis is to investigate the effects of strategic alliances on market outcomes and economic welfare.

Chapter 2 reviews the history of alliances, examines their current status, and discusses the future evolution of alliances. Based on analysis of 46 alliances, it seems likely that strategic alliances will continue to expand and form global airline networks. Consequently, a limited number of future global networks will likely be formed by alliances composed of airlines from each continent.

Chapter 3 develops theoretical models to examine the effects on firms' outputs and profits, and economic welfare of different types of alliances: "complementary" and "parallel" alliances. The complementary alliance refers to the case where two carriers link their networks to feed traffic to each other. The parallel alliance refers to collaboration between two carriers competing on the same route. We find that the two types have different effects on total output and consumer surplus. We identify sufficient conditions under which each type of alliance improves total welfare. Empirical test results confirm the theoretical predictions concerning partners' outputs and total output.

Chapter 4 empirically examines the effects on air fares, passenger volume, service quality, and partners' stock values and traffic of four major alliances in the North Atlantic market: British Airways-USAir, Delta-Sabena-Swissair, KLM-Northwest, and Lufthansa-United. Equilibrium traffic increases by an average of 35,998 passengers annually, while equilibrium air fares decrease, on average, by $41 on alliance routes. As a result, consumer benefits increase by $130 million, a 12 per cent increase over the without-alliance consumer surplus level during the post-alliance period. Schedule delay times are also reduced, owing to the alliances. Partners' stock values are positively affected by alliance announcements and by alliance operations. Most partners have experienced greater traffic increases on alliance routes than those on non-alliance routes.

Government agents should be cautious before granting antitrust immunity to would-be parallel alliance partners. However, the international aviation market could become more competitive by approving more complementary alliances and promoting competition among alliance groups.
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CHAPTER 1. INTRODUCTION

1.1 MOTIVATION

The world aviation industry is undergoing major structural changes. Major airlines have sought to build global airline networks to attract more passengers from all over the world. Most consumers prefer airlines serving a large number of points to ones serving a smaller number of points. This preference has induced airlines to establish global airline networks. The aviation industry will eventually globalize (Tretheway and Oum, 1992).

Until recently, some mega carriers have tried to create global airline networks by adding foreign spokes to their domestic hub cities. However, it is almost impossible for a single airline to create a truly global network. A foreign carrier will face greater constraints in setting up an efficient hub-and-spoke network in a foreign territory than would a resident. Even if possible, enormous funds and time would be required to build such networks in foreign continents. There are also legal constraints on mergers and acquisitions between airlines of different nations. By law, foreign carriers may not own more than 25 per cent

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1 Reasons for this preference are: (i) consumers can minimize their own cost of route planning since an airline with an extensive network can serve virtually all destinations; (ii) consumers can receive higher quality of service such as online connections; (iii) more attractive frequent flyer program (see Tretheway and Oum, 1992, pp.17-18).

2 Oum, Taylor and Zhang (1993) predict that a successful global network will likely generate more than $30 billion in revenue. Creating a single organization for an agency of this size would require financial resources beyond the reach of even the largest existing carrier. Mega-carriers in North America (American, United, and Delta), Europe (British Airways, and Lufthansa), and Asia (Japan Airlines) had annual revenues ranging between $8 billion and $15 billion in 1993.
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of voting shares of any airline in the US, Canada, and Australia. Current bilateral agreements\(^3\) are another impediment. Airlines cannot simply fly wherever they want to. For example, the present agreement between the US and the UK specifies that only two US airlines can serve London Heathrow airport, a key gateway for traffic between the US and both Europe and the Middle East.

In order to get around these constraints, airlines have increasingly formed strategic alliances\(^4\) with foreign airlines. As of June 1996, more than 380 strategic alliances existed between 171 international airlines (Airline Business, July 1996). More than 50 strategic alliances have emerged yearly. Strategic alliances enable partners involved to expand the reach of their networks and services to many parts of the world where it may not be economical to do so on their own or where there may be a lack of authority to operate their own flights.

Strategic alliances have both pro- and anti-competitive impacts on markets. Alliances provide opportunities for partners to reduce costs by linking their networks, and/or integrating activities in various fields. Consequently, the partners may become more cost-effective and increase their competitiveness against non-participating carriers.

\(^3\) Under a framework established by most allies and neutral countries gathered at the 1944 Chicago Convention, current international air travel is largely governed by bilateral agreements. Bilateral agreements between two countries generally specify that participating carriers be substantially owned by nationals of the home country involved. This provision prevents a third nation from participating under the bilateral umbrella when one of the two nations elects not to exercise its own rights.

\(^4\) Strategy literature defines an alliance as any governance structure where two or more firms agree to collaborate on a project or to share information or resources (e.g., Besanko, Dranove and Shanley, 1996, p. 158). The literature frequently uses "strategic alliance" instead of "alliance" to distinguish the alliance between firms from "military alliance." This thesis follows the tradition of the strategy literature. However, empirical analysis in Chapter 4 will focus on major strategic alliances in the North Atlantic market.
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Alliances also enable partners to provide passengers with better quality of services. Partners can adjust arrival and departure flight schedules at connecting airports to reduce layover time between connections. They can re-locate departure gates for connecting flights near arrival gates to decrease connecting distances. Linking partner networks may increase demand for origin and destination markets newly connected by alliances.

Although benefits from alliances have been recognized, there are also some concerns about potential anticompetitive effects of alliances, particularly, the possibility of collusion between partners which is harmful to consumers. Some alliances may reduce the number of competitors and thus increase combined market power of aligned partners. As a result, the partners may increase air fares if they behave collusively and exploit their strengthened market power. In some cases, an alliance may cause demand decreased if the partners decrease combined number of flights.

As described in Chapter 2, it is expected that a limited number of global airline networks will be developed by a group of airlines from each continent. Major carriers from each continent will be senior partners, while a number of junior partners from each continent will feed traffic to trunk networks linking seniors' existing hubs. Being a senior partner in a successful alliance is very important, not only for the carrier's future, but also for the nation's economy. At this juncture, it is crucial for each major carrier to engage in a proper strategy for participating in a successful alliance. It is also crucial for each regulatory agency to make proper policy choices to support its carriers and to secure long-term benefits to consumers. For example, a poor policy choice may make it difficult for its carrier to
remain a major carrier in the future. Some major carriers today may end up becoming regional feeders or niche carriers once global alliance networks are completed.

Therefore, it is very important for academics and practitioners to understand the effects of strategic alliances on airlines (participating and non-participating), consumers, and economic welfare. The main purpose of this thesis is to investigate the effects on market outcomes and welfare of strategic alliances occurring in the international airline industry. To the best of our knowledge, few researchers have devoted efforts to constructing theoretical models of strategic alliances in order to examine the effects of alliances on market outcomes and welfare. We develop theoretical models to evaluate the impacts of different types of strategic alliances. We also empirically examine the effects of alliances on air fares, passenger volume, service quality, and alliance partners' stock values and traffic.

1.2 LITERATURE REVIEW

In the late 1980s and early 1990s, firms increasingly turned to strategic alliances as a way to collectively organize complex business transactions without sacrificing autonomy. Strategic alliances have occurred in a broad spectrum of industries including the airline, automobile, commercial aircraft, electronics, pharmaceutical, robotics, steel, and telecommunications industries (Business Week, July 27, 1992; and Economist, September 11, 1993). It is natural that strategic alliances have received growing attention from many academics and practitioners. Consequently, a number of alliance studies have been published in strategy and organization literature. These studies mainly deal with the following four
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issues of strategic alliances: (i) importance of strategic alliances in a globalized economy, (ii) reasons for alliance formations, (iii) critical success factors of alliances, and (iv) governance forms of alliances. In what follows, we briefly review some literature regarding each issue.

Ghoshal (1987), and Harrigan (1987) argue that strategic alliances are critical mechanisms for competing in global markets and coping with the increasingly rapid pace of technological development. Ohmae (1989) contends that strategic alliances are a necessity and not just a fad or a fashion, suggesting that firms should find partners that can help amortize immense fixed costs in order to compete more effectively in the global arena. Narus and Anderson (1996) also place emphasis on the importance of strategic alliances in the increasingly competitive environment. They argue that by sharing resources in novel ways, firms can take advantage of opportunities that they could not exploit alone.

Hamel, Doz and Prahalad (1989), and Mowery and Teece (1993) identify two primary reasons for firms to form strategic alliances: to acquire new technologies or skills, and to reduce the costs of entering new businesses or markets. Conducting case studies of 15 strategic alliances around the world, Hamel, Doz and Prahad (1989) reach a conclusion that Japanese companies made greater efforts to learn than western partners whose main purpose was to avoid investment. Mowery and Teece (1993) find that foreign firms formed strategic alliances with Japanese firms in order to improve their access to Japanese technology and markets.

Some researchers in strategy field investigate conditions under which strategic
alliances are more likely to occur than mergers and acquisitions (e.g., Hennart, 1988; and Kogut and Singh, 1988). The issue was recently revisited by Hennart and Reddy (1997). They conduct discriminant analysis on Japanese manufacturing entries in the US during the 1978-89 period in order to identify determinants of choice between strategic alliances and acquisitions. They find that the degree of indivisibility of desired assets from nondesired assets is one of the major determinants, and argue that strategic alliances are more likely to occur than acquisitions when desired assets, which an investor needs, are hard to disentangle from nondesired assets.

Some studies have examined critical success factors required for implementation of strategic alliances (e.g., Lei and Slocum, 1991; and Ellis, 1996). Lei and Slocum (1991) examine critical success factors for each of the three broad types of strategic alliances (licensing arrangements, joint ventures, and consortia). According to Ellis (1996), creating an environment of trust is critical for a strategic alliance to succeed.

An extensive body of studies published in organization literature has examined governance forms of alliances. These studies have found that governance forms are important in influencing the success of alliances and promoting their cooperation (e.g., Harrigan, 1988; Borys and Jemison, 1989; and Osborn and Baughn, 1990). Osborn and Baughn (1990) empirically analyze some factors affecting choice between joint ventures and

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5 According to strategy and organization literature, a joint venture is a particular type of strategic alliance in which two or more firms create, and jointly own, a new independent organization. However, the definition of strategic alliance is slightly different in transportation literature where a strategic alliance is defined as strategic collaboration between airlines while maintaining their identity, excluding joint ventures from the strategic alliance category. This thesis follows the definition used in the transportation literature.
contractual agreements. From the transactions cost perspective, they regard joint ventures as quasi-hierarchies and contractual agreements as quasi-markets. They find that high technological intensity is associated with contractual agreements and the intention to conduct joint R&D with joint ventures. Parkhe (1993a and 1993b), based on a prisoners' dilemma framework, develops an analytical model where alliance structure is related to its performance. These papers also provide empirical support for the linkage between the structure and performance.

However, there are two important limitations in these studies. First, most alliance studies in strategy and organization literature do not control industry-specific effects. Different industry conditions may alter preferences for alliance formation and thus governance forms of alliances. For example, Osborn and Baugn (1990) analyze 153 strategic alliances in 13 industries during the 1984-86 period. Hennart and Reddy (1997) analyze 244 strategic alliances in 16 industries during the 1978-89 period. Another significant limitation of the studies is that few studies have focused on the linkage between alliance formation and its effects on market outcomes and welfare.

In order to control industry-specific effects, we focus our attention on strategic alliances in the international aviation industry. Despite the growing importance of international airline alliances, there have been a few alliance studies in transportation

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6 Transactions costs include the time and expense of negotiating, writing, and enforcing contracts. Transactions costs arise when one or more parties to a transaction have a chance to act opportunistically. Under transactions cost theory, incentives to exploit opportunistic behaviour can be reduced when the parties place transactions in a single hierarchy (Besanko, Dranove and Shanley, 1996, p.121). According to transactions cost theory, balancing efficiency and protection leads firms to select a mix of markets and hierarchies to manage transactions (Osborn and Baughn, 1990).
literature. Oum, Taylor and Zhang (1993) argue that strategic alliances will play an important role in forming global airline networks. Youssef and Hansen (1994) empirically investigate the effects of the strategic alliance between SAS and Swissair on service quality and market concentration. Gellman Research Associates (1994) measures the impacts of two strategic alliances (British Airways-USAir and KLM-Northwest) on market share and welfare. One critical drawback of these empirical studies is that they do not appropriately distinguish pre- and post-alliance situations. Since structural changes can occur due to strategic alliances, it is required to capture the structural changes in order to identify the effects of the alliances. Oum, Park and Zhang (1996) examine the effects of codesharing agreements on firm conduct and air fares by focusing on trans-Pacific markets. This study is limited due to lack of data as it focuses on impacts on non-aligned carriers, and excludes impacts on aligned partners.

1.3 OVERVIEW OF THESIS

Even those who closely follow the aviation industry have difficulty in keeping up with the current status of strategic airline alliances because of constant changes. The purpose of Chapter 2 is to review the history of strategic alliances, to examine their current status, and to conjecture the role of strategic alliances in the formation of future global airline networks.

For a better understanding of the current status and the future, we need to understand the history of strategic alliances. To this end, Section 2.2 reviews alliance histories in the US and Europe from government policy perspectives. Initially, the US had a generous view
towards strategic alliances between US and foreign carriers, where approval proceedings were not required as long as both carriers had operating rights on routes involved. The US government changed its position in December 1987. It required that strategic alliances involving US carriers be approved by the government for the sake of the nation's public interest. In contrast, the European Union does not require approval proceedings for international alliances between EU carriers since the EU regards strategic alliances as private marketing agreements. Despite this contrast of approval proceedings, both the US and EU believe that strategic alliances facilitate competition among international carriers in the liberalizing, but still restricted, international aviation markets.

Section 2.3 provides an overview of the current status of alliances. Emergence of strategic alliances has dramatically increased since the early 1990s. Moreover, forty-six alliances among the world's top-30 airlines are examined in detail in order to identify the areas of joint activities between partners and the types of alliances. The top airlines are chosen on the basis of rank of scheduled revenue passenger-kilometres performed in 1994. The following areas of joint activities are identified from the case analysis: coordination in ground handling, joint use of ground facilities, shared frequent flyer programs, codesharing or joint operations, block space sales, coordination of flight schedules, exchange of flight attendants, joint development of systems or systems softwares, joint advertising, joint maintenance, joint purchase of aircraft/fuel, etc. Based on the extent of coordination in these areas, the forty-six alliances are classified into three categories, ranging from simple route-by-route alliances (28 cases) to broad commercial alliances (9 cases) and to equity
alliances (9 cases). The degree of integration gets stronger in alliances involving equity investment, as compared to alliances without equity investment.

In Section 2.4, we briefly examine economic and strategic reasons why airlines have been eagerly participating in the alliance race. The reasons can be summarized as: (i) network expansion by linking partners' networks, (ii) increased traffic feed between partners, (iii) cost effectiveness through network expansion and joint operation, (iv) provision of higher quality of services, (v) increased itinerary choices for passengers, and (vi) competitive advantages on computer reservation system displays.

Based on past history and current trends, Section 2.5 provides three conjectures for the future evolution of alliances. First, it seems likely that global airline networks will not be formed by individual carriers, but by a group of airlines from each continent. Thus, the prevailing alliance race will likely continue unless foreign ownership laws and nationality clauses in bilateral agreements change. The second conjecture is that major strategic alliances will solidify in that each partner will adhere to one major strategic alliance group. Because of the enormous size of the US market, each alliance would include a major US carrier. Each alliance would also include one major European carrier and/or one major Asian carrier. Therefore, it is expected that a limited number of future global airline networks will be formed by strategic alliances composed of airlines from each continent.

Chapter 3 builds a theoretical model to examine effects on firms' outputs and profits, and economic welfare of different types of strategic alliances: "complementary" and "parallel" alliances. The complementary alliance refers to the case where two carriers link
their existing networks and build a new complementary network in order to feed traffic to each other. The KLM/Northwest alliance can be regarded as this type.

The parallel alliance refers to collaboration between two carriers competing on the same route. Two types of parallel alliances are considered: "no shut-down" and "shut-down" parallel alliances. Each partner continues to provide non-stop services on the route in the first type, while two partners integrate their non-stop services in the second type. For example, Air Canada and Korean Air implemented a "no shut-down" parallel alliance on the Vancouver-Seoul route. Delta and Sabena formed a "shut-down" parallel alliance on the New York-Brussels route whereby Delta discontinued flights after the alliance.

In Section 3.2, a simple network structure, consisting of three gateway cities located in different countries, is considered. While this is a highly simplified structure, this network structure captures complementarity between local and connecting services, which is key to analyzing the effects of strategic alliances. It is assumed that three international airlines are operating in the network. Next, pre-alliance, complementary alliance, and parallel alliance conditions are constructed, and the Basic Model, where there is no demand shift due to the alliances, is developed. The effects of strategic alliances are examined in multi-firm and multi-market context. Thus, this approach can be applied to strategic alliances in any other network industry such as the telecommunications industry.

Section 3.3 examines the effects of a complementary alliance on market outcomes and total welfare. It is found that the complementary alliance in a specific market has indirect positive (negative, respectively) effects on the partners' (non-partner's, respectively) outputs.
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in other markets. The complementarity between local and connecting services is crucial for this result. Coordination in connecting markets enables the partners to increase service quality and decrease average operating costs in local markets. This is possible since multiple products are serviced through the same network.

Based on a symmetry assumption, it is shown that the complementary alliance increases total output and decreases "full" prices, resulting in increased consumer surplus. We find sufficient conditions under which the complementary alliance improves total welfare. Given the symmetry of the partners and non-partner, total welfare can rise if the partners can coordinate to the extent that they are able to provide the same level of connecting services as the non-partner's.

Section 3.4 deals with the effects of the parallel alliances on the partners' outputs and total welfare. In the case of the "no shut-down" parallel alliance, we need to compare the individual-profit-maximization (pre-alliance) situation to the joint-profit-maximization (post-alliance). Since the "overall" effect involves switching from one situation to another, it is hard to directly sign the effect. To avoid this difficulty, we instead analyze the infinitesimal effect of the "no shut-down" parallel alliance. The "no shut-down" parallel alliance is likely to decrease total output on the alliance route. Consequently, consumer surplus is likely to decrease.

In the case of the "shut-down" parallel alliance, it is intractable to compare pre- and post-alliance situations under general specifications since the numbers of the first-order conditions between the two situations are not the same. For tractability of analysis, we
impose more structure on demand and cost specifications. By and large, directional effect of "shut-down" parallel alliance is similar to that of "no shut-down" parallel alliance.

By relaxing the assumption that there is no exogenous demand shift due to alliances, Section 3.5 extends the Basic Model to capture codesharing effect on demand shifts. For the complementary alliance case, we find that the codesharing effect on the partners' demand shifts does not change the results derived from the Basic Model, as long as there is no shift in the non-partner's demand. For the parallel alliance where both partners' demand functions are shifted upward, it is possible for both partners to simultaneously increase output on the alliance route, resulting in increased total output and thus increased consumer surplus.

In Section 3.6, we test some predictions associated with the effects on each firm's outputs and total output. The test results are generally consistent with the theoretical predictions concerning partners' outputs and total output. The test results indicate that the partners' traffic increases in a complementary alliance, while the partners' traffic decreases in a parallel alliance. The results also show that total traffic increases by an average of 11-17 per cent of the average total traffic due to a complementary alliance, while total traffic decreases by an average of 11-15 per cent of the average in the case of a parallel alliance.

As shown in the Extended Model in Chapter 3, whether or not there is a demand shift due to an alliance plays an important role in assessing the effects of the alliance, particularly in the parallel alliance case. It appears to be an empirical question whether or not there is a demand shift due to an alliance. Chapter 4 is an empirical study of strategic
alliances in the North Atlantic market. Chapter 4 investigates the effects of four alliances on air fares, passenger volume, service quality, and alliance partners' stock values and traffic by using panel data on North Atlantic routes for the 1990-94 period or using financial market data. The North Atlantic markets are very important not only because these are the largest intercontinental markets, but also because major strategic alliances involving US carriers have been formed in these markets. The strategic alliances under consideration are British Airways and USAir (BA/USAir), Delta, Sabena and Swissair (DL/SN/SR), KLM and Northwest (KLM/NW), and Lufthansa and United Airlines (LH/UA).

To better understand the empirical study, Section 4.2 provides detailed information on these four strategic alliances. The four alliances together have more than a 60 per cent share of the entire North Atlantic market, as measured by scheduled revenue passenger-kilometres. As shown in Table 4.1, each of the alliances has different characteristics. Thus, the empirical analysis is conducted by treating each alliance as a unique case.

A methodology examining structural changes due to strategic alliances is provided in Section 4.3. The methodology is an improvement over previous studies in the following respects. First, the empirical model is derived from the firm's profit maximization behaviour in order to achieve consistency between the model building and estimation procedures.

Second, both price and passenger volume are treated as endogenous variables in a system of demand and price equations since they mutually influence each other in the equations. Although this approach makes the estimation procedure more complex, it
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captures the mutual interaction between the two variables and allows us to find equilibrium price and passenger volume properly.

Third, this empirical study appropriately deals with the markup-ratio term of price equation when estimating the system of equations. Previous empirical studies have estimated price equations using either a single equation approach or using a multiple equations approach without explicitly incorporating the markup term in the price equation (e.g., Graham, Kaplan and Sibley, 1983; Borenstein, 1989; Dresner and Tretheway, 1992; Evans and Kessides, 1993; and Maillebiau and Hansen, 1995).

Fourth, the effects of alliances are measured in a more complete way. Proper identification of the effects requires a comparison of with- and without-alliance situations, after taking into account structural changes caused by alliances. This requires us to include data for both pre- and post-alliance periods for estimating the model. Previous empirical studies on strategic alliances do not appropriately handle this issue (e.g., Youssef and Hansen, 1994; and Gellman Research Associates, 1995).

Section 4.4 presents the effects of alliances on air fares and passenger volume on alliance routes. The estimation results reported in Table 4.5 show that structural changes occur in demand and price equations due to the alliances. More specifically, the BA/USAir, KLM/NW, and LH/UA alliances shift up the demand function on respective alliance routes during post-alliance periods, whereas the DL/SN/SR alliance shifts down the demand function during its post-alliance period. It is also estimated that only two alliances (KLM/NW and DL/SN/SR) significantly shift down their price equations on respective
alliance routes during post-alliance periods.

Based on the estimation results, a counterfactual scenario analysis is conducted to measure changes in air fares, annual passenger volume, and consumer surplus due to the alliances. The estimation results on changes in passenger volume are consistent with the theory in Chapter 3. By and large, those alliances which have some degree of complementary alliance characteristics increase passenger volume, while the shut-down parallel alliance, DL/SN/SR, decreases passenger volume. Altogether, average annual passenger volume increases by 35,998 passengers, while air fares, on average, decrease by $41 on the alliance routes. These changes increase consumer benefits by $130 million during the post-alliance period.

Previous works have found that a passenger's schedule delay time is one of the most important aspects of service quality (Morrison and Winston, 1986; and Winston, 1993). In Section 4.5, pre- and post-alliance schedule delay times for each of the four alliances are compared to examine whether or not schedule delay times decrease due to the alliances. Although schedule delay times are generally reduced, only the effects of KLM/NW and LH/UA are estimated as significant.

Section 4.6 investigates the effects on alliance partners' stock values of the announcement of a new alliance and of the operation of that alliance. The former effect is referred to as the "announcement effect," and the latter as the "operation effect."

The announcement effect is measured by the event-study methodology. For all carriers, positive announcement effects are identified. However, positive announcement
effects are estimated as significant only for BA and KLM.

The operation effect is measured by comparing pre- and post-alliance stock price trends. Strong, positive operation effects are identified for most carriers under consideration. For example, for USAir and SR, we find sharp increases in adjusted stock prices at the initial points of alliance operation. For BA and DL, stock prices increase more steeply during post-alliance periods, as compared to stock price increases during pre-alliance periods.

Section 4.7 examines the effects of alliances on alliance partners' traffic. Changes in partners' traffic on alliance routes are compared to those on non-alliance routes. The partners' traffic on alliance routes is likely to increase more than traffic increases on non-alliance routes should their partner feed traffic onto the alliance routes, not onto the non-alliance routes. This may be one of the reasons why the partners maintain their relationship. As expected, most of the partners under consideration have greater traffic increases on their alliance routes than those on their non-alliance routes.

Chapter 5 summarizes this thesis, discusses policy implications, and suggests future research opportunities.
CHAPTER 2. THE HISTORY, CURRENT STATUS, AND FUTURE EVOLUTION OF STRATEGIC ALLIANCES

2.1 INTRODUCTION

This chapter reviews the history of strategic alliances, examines their current status, and conjectures the role of strategic alliances in the formation of future global airline networks. The chapter addresses the following specific questions: How do policy makers feel about ongoing strategic alliances? Do they support alliances or seek to restrain airlines from forming alliances? What makes airlines form strategic alliances? Which areas do alliance partners coordinate and how deeply? How will future global airline networks evolve? How will strategic alliances affect the formation of global networks?

Section 2.2 reviews alliance histories from policymakers' perspectives. US and European policies are reviewed. Section 2.3 outlines the current status of alliances, and analyzes areas of joint activities between partners. Forty-six alliances among the world's top-30 airlines are examined in detail to identify areas of joint activities and types of alliances. Section 2.4 examines economic and strategic reasons why airlines have been eagerly participating in the alliance race. Based on past and current trends, Section 2.5 predicts the future evolution of alliances. Concluding remarks for this chapter are provided in Section 2.6.
2.2 ALLIANCE HISTORY AND GOVERNMENT POLICY

2.2.1 United States

The first domestic alliance in the US occurred in 1967. Allegheny Airlines (now US Air) shifted from propeller-driven aircraft to jets in that year. Larger aircraft were uneconomical to operate on low-density routes, but the airline could not simply pull out of these markets because of regulations by the now defunct Civil Aeronautic Board (CAB). Allegheny Airlines formed contracts with commuter airlines to operate services on its behalf from major cities to small towns. Commuter flights in this system carried Allegheny's "AL" code designation. This allowed Allegheny to achieve lower operating costs. Unlike today, the primary objective of this alliance was not to gain market access, but to provide replacement service.

The first international alliance was formed in 1986 between Air Florida and British Island. Air Florida fed US originating traffic to British Island's flights on the London-Amsterdam route where both airlines codeshared. At that time, the US Department of Transportation (US DOT) had a generous policy toward international codesharing alliances.\(^1\) It did not require approval proceedings as long as both US and foreign carriers had underlying route authority to the cities involved (Hadrovic, 1990).

However, the US DOT changed its position in December 1987 when United Airlines

---

\(^1\) A codesharing agreement is a marketing agreement between two airline partners whereby one airline's designator code is shown on flights operated by its partner airline. Codesharing agreements allow each airline involved to provide services with its partner's flights, even though it does not operate its aircraft. For example, Canadian Airlines and Qantas have a codesharing agreement on the Vancouver-Honolulu-Sydney route where Canadian serves the Vancouver-Honolulu section and Qantas serves the Honolulu-Sydney section of the route.
(UA) and British Airways (BA) proposed codesharing on UA flights in the Chicago-Seattle market as an extension of its London-Chicago service. BA already had route authorities on the London-Chicago-Seattle route, but the US DOT advised the airlines that it would need authorization for the proposed codesharing alliance. UA responded by filing for an exemption, claiming that the codesharing alliance was consistent with public interests.

In March 1988, the US DOT granted the exemption, saying that its regulations had been unclear and that the codesharing alliance was in the public interest. At the same time, the US DOT clarified its position on international alliances. It declared that an international alliance would not be approved by the US DOT unless it was covered in a bilateral agreement or otherwise brought benefits to the US and unless the foreign country allowed US carriers codesharing rights in its markets (Gellman Research Associates, 1994, p.29).

Recently, permission of international alliances was used to change some aspects of existing bilateral agreements. For example, the current US-UK bilateral agreement permits only two carriers from each country to operate to London Heathrow airport. Initially, TWA and Pan Am had that authority. However, both TWA and Pan Am experienced severe financial difficulties in 1991. The major issue was which US carriers would take over TWA and Pan Am's rights to serve Heathrow airport. American and United were interested in purchasing their operations. The UK government and BA were reluctant to grant such authorities since American and United were regarded as potentially much stronger competitors than TWA and Pan Am. In exchange for agreeing to amend the bilateral agreement so that American and United could obtain the rights, the UK insisted on
codesharing authority in US domestic markets for BA and other British carriers. Consequently, the BA/USAir partnership was formed in 1993, allowing BA to be able to connect London to USAir's domestic network.

More recently, antitrust immunity\(^2\) has been granted to existing international alliances in order to facilitate open skies agreements with other countries. Initially, the US hoped that an open skies agreement might be possible with the entire European Union. After failing its initial attempts, it changed its approach to open skies and focused on agreements with individual countries.\(^3\) In order to accelerate open skies agreements, the US granted antitrust immunity to existing strategic alliances between US and foreign carriers. For example, shortly after the US and Netherlands signed an open skies agreement in September 1992, Northwest and KLM were granted antitrust immunity by the US DOT in November 1992. Another example is when Lufthansa and United received antitrust immunity in May 1996 in exchange for an open skies agreement between the US and Germany in February 1996. The US DOT believes that granting antitrust immunity would permit alliance partners to operate

\(^2\) US antitrust laws are designed to protect consumers by prohibiting competitors from colluding and engaging in anticompetitive behaviour such as jointly setting prices. Thus, the antitrust laws limit the level of integration that competing airlines can achieve. However, the Secretary of Transportation has the authority to grant antitrust immunity to agreements in foreign air transportation if the agreements would not result in a substantial lessening of competition and achieve important public benefits. Regarding antitrust immunity, the US DOT has the sole right to decide whether or not to approve immunity requests by carriers, and the US Department of Justice only has the authority to screen applications by alliance partners based on their impact on competition.

\(^3\) It has had only limited success, as only some of the relevant countries have agreed to have open skies with the US. These countries are Austria, Belgium, Canada, Denmark, Finland, Germany, Iceland, Luxembourg, the Netherlands, Norway, and Switzerland. Signing with these countries, the US hoped that increased competition and services would force other surrounding countries to follow suit. The US will continue its efforts as there are some countries that are willing to open up more capacity to US carriers in exchange for increased access to US markets.
more efficiently, provide better services to the US travelling and shipping public, and allow
US carriers to compete more effectively with other global alliances. This is consistent with
its policy of facilitating competition among multinational airline networks.

2.2.2 European Union

The European Union (EU) consists of fifteen member states, including Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the UK. Until the mid 1980s, bilateral agreements among the members had governed international aviation policies within the Union as well as outside the Union. Since then, there has been a move to making the EU a single market by liberalizing the bilateral agreements among the members. For example, from January 1993, any EU carrier was able to fly between member states without restriction. Foreign ownership laws were also reformed to make foreign participation easier. Consequently, there has been considerable increases in equity investment alliances within the Union.4

Unlike the US, the EU does not require approval proceedings for international codesharing and/or block space agreements within the Union, but rather examines their impacts on competition. EU carriers are allowed to enter into alliances unless they result in a virtual monopoly. They are generally free to enter into such agreements anywhere within the Union (McNeil, 1993). To date, EU carriers can also codeshare on

4 For further discussion, see, for example, Button (1996).
intercontinental routes to destinations where both EU and non-EU carriers have route authority. The European Commission has yet to decide whether to regulate international alliances in the future (Australian Bureau of Transport and Communications Economics (BTCE), 1996, p.28).

However, individual EU states have different perspectives with respect to codesharing operations. The UK and the Netherlands have never objected to codesharing agreements, whereas some other members have placed restrictions on certain types of codesharing operations. Both the UK and the Netherlands claim that a codesharing operation should be a private marketing right rather than a traffic right (Feldman, 1988). In contrast, Italy prohibits codesharing operations on fifth freedom routes unless a bilateral agreement provides for change of gauge rights. In the future, individual European countries would be expected to be supportive of international alliances since their carriers wish to obtain better access to points beyond the international gateways in the US (BTCE, 1996, p.29).

Since the EU has some concerns about the anticompetitive impact of codeshared flights on competition, the EU has limited the number of codeshared flights on computer reservation systems (CRSs) twice, i.e., once under each partner's code (US General Accounting Office (US GAO), 1995, p.59). In Europe, it is required for CRSs to clearly

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5 Fifth freedom is the right to carry traffic from the home country to a foreign country, pick up traffic in the foreign country, and carry it to another foreign country.

6 Change of gauge rights allow an airline to use aircraft on one sector of a route which is different in capacity from that used on another sector of the route.

7 Although the US DOT proposed regulations in August 1994 aimed at ensuring that consumers are notified of which airline is the actual operator before taking a codeshare flight, neither the US DOT's regulations nor its proposed rules limit the number of times a codeshare flight may be listed on CRS screen
identify the airline actually operating the flights. The European Code of Conduct for CRSs also specifies the order in which flights are displayed, with direct non-stop services, followed by direct stop services and then connecting services.

### 2.3 CURRENT STATUS AND AREAS OF COOPERATION

#### 2.3.1 Current status of alliances

Table 2.1 provides an overview of the current status of strategic alliances. The total number of strategic alliances as of 1996 was 389, a net increase of more than 19 per cent over 1995 and 39 per cent over 1994. In 1994, 280 alliances existed among 136 carriers. Since then, 35 additional airlines have joined the alliance race. More than 50 new agreements have been reached on joint services every year since 1994. A list of such agreements includes those of Air France with Japan Airlines (May 1994); Canadian Airlines with Malaysia Airlines (November 1995); and Air Canada with Lufthansa (March 1996). Also, new agreements have been extended from Asia/Pacific, European and North American regions to new regions such as Latin America, the Caribbean and Africa (ICAO Journal, 1994).

However, the proportion of alliances involving equity investments declined over the period. Table 2.1 shows the percentage of equity alliances in 1996 decreased by about 5 per cent from 20.7 per cent in 1994.

## TABLE 2.1 Current Status of Alliances

<table>
<thead>
<tr>
<th></th>
<th>'96</th>
<th>'95</th>
<th>'94</th>
<th>annual average growth rate (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of alliances</td>
<td>389</td>
<td>324</td>
<td>280</td>
<td>17.9%</td>
</tr>
<tr>
<td>number of airlines</td>
<td>171</td>
<td>153</td>
<td>136</td>
<td>12.1%</td>
</tr>
<tr>
<td>with equity stakes</td>
<td>62</td>
<td>58</td>
<td>58</td>
<td>3.4%</td>
</tr>
<tr>
<td>without equity</td>
<td>327</td>
<td>266</td>
<td>222</td>
<td>21.4%</td>
</tr>
<tr>
<td>percentage of equity alliance(%)</td>
<td>15.9</td>
<td>17.7</td>
<td>20.7</td>
<td></td>
</tr>
<tr>
<td>new alliances</td>
<td>71</td>
<td>50</td>
<td>n/a(b)</td>
<td>42.0%</td>
</tr>
</tbody>
</table>

(Source) Airline Business (1994-96)

(Notes)

(a) The annual average growth rate is calculated between 1994 and 1996.
(b) n/a means "not available".

Table 2.2 shows equity investment alliances in which both investor and invested carriers are North American, European, and/or Asian carriers. European carriers tend to be involved in equity investment alliances more frequently than North American and Asian carriers. In general, large carriers invest in smaller carriers to make the latter closely coordinate with the former and thus make alliance arrangements more permanent.
### TABLE 2.2 Equity Investment Alliances (as of July 1996)

<table>
<thead>
<tr>
<th>Investor Airlines (a)</th>
<th>Invested Airlines</th>
<th>Equity Holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Canada (Canada)</td>
<td>Continental Airlines (USA)</td>
<td>27.5 (b)</td>
</tr>
<tr>
<td>Air France (France)</td>
<td>Austrian Airlines (Austria)</td>
<td>1.5</td>
</tr>
<tr>
<td>Air France (France)</td>
<td>Middle East Airlines (Lebanon)</td>
<td>28.5</td>
</tr>
<tr>
<td>Air India (India)</td>
<td>Air Mauritius (Mauritius)</td>
<td>8.5</td>
</tr>
<tr>
<td>Air New Zealand (New Zealand)</td>
<td>Air Pacific (Fiji)</td>
<td>2.0</td>
</tr>
<tr>
<td>Alitalia (Italy)</td>
<td>Malev Airlines (Hungary)</td>
<td>30.0</td>
</tr>
<tr>
<td>All Nippon Airways (Japan)</td>
<td>Austrian Airlines (Austria)</td>
<td>9.0</td>
</tr>
<tr>
<td>American Airlines</td>
<td>Canadian Airlines (Canada)</td>
<td>33.3</td>
</tr>
<tr>
<td>British Airways (UK)</td>
<td>Air Mauritius (Mauritius)</td>
<td>12.8</td>
</tr>
<tr>
<td>British Airways (UK)</td>
<td>Deutsche BA (Germany)</td>
<td>49.0</td>
</tr>
<tr>
<td>British Airways (UK)</td>
<td>Qantas Airways (Australia)</td>
<td>25.0</td>
</tr>
<tr>
<td>British Airways (UK)</td>
<td>TAT European Airlines (France)</td>
<td>49.9 (c)</td>
</tr>
<tr>
<td>British Airways (UK)</td>
<td>USAir (USA)</td>
<td>24.6</td>
</tr>
<tr>
<td>Delta Air (USA)</td>
<td>Singapore Airlines (Singapore)</td>
<td>5.0</td>
</tr>
<tr>
<td>Delta Air (USA)</td>
<td>Swissair (Switzerland)</td>
<td>4.5</td>
</tr>
<tr>
<td>Iberia (Spain)</td>
<td>Aerolineas Argentinas (Argentina)</td>
<td>5.0</td>
</tr>
<tr>
<td>Iberia (Spain)</td>
<td>Ladeco Chilean (Chile)</td>
<td>25.0</td>
</tr>
<tr>
<td>Iberia (Spain)</td>
<td>Viasa Venezuelan (Venezuela)</td>
<td>45.0</td>
</tr>
<tr>
<td>Japan Airlines (Japan)</td>
<td>Hawaiian Airlines (USA)</td>
<td>8.5</td>
</tr>
<tr>
<td>KLM (Netherlands)</td>
<td>Air UK (UK)</td>
<td>45.0</td>
</tr>
<tr>
<td>KLM (Netherlands)</td>
<td>Kenya Airways (Kenya)</td>
<td>26.0</td>
</tr>
</tbody>
</table>
### TABLE 2.2 (Continued)

<table>
<thead>
<tr>
<th>Investor Airlines(a)</th>
<th>Invested Airlines</th>
<th>Equity Holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td>KLM (Netherlands)</td>
<td>Northwest Airlines (USA)</td>
<td>49.0</td>
</tr>
<tr>
<td>Lufthansa (Germany)</td>
<td>Lauda Air (Austria)</td>
<td>39.7</td>
</tr>
<tr>
<td>Malaysia Airlines</td>
<td>World Airways (USA)</td>
<td>25.0</td>
</tr>
<tr>
<td>Qantas (Australia)</td>
<td>Air New Zealand (New Zealand)</td>
<td>19.4</td>
</tr>
<tr>
<td>SAS (Sweden)</td>
<td>British Midland (UK)</td>
<td>40.0</td>
</tr>
<tr>
<td>Singapore (Singapore)</td>
<td>Delta Air (USA)</td>
<td>5.0</td>
</tr>
<tr>
<td>Swissair (Switzerland)</td>
<td>Swissair (Switzerland)</td>
<td>2.7</td>
</tr>
<tr>
<td>Swissair</td>
<td>Austrian Airlines (Austria)</td>
<td>10.0</td>
</tr>
<tr>
<td>Swissair</td>
<td>Delta Air (USA)</td>
<td>5.0</td>
</tr>
<tr>
<td>Swissair</td>
<td>Sabena (Belgium)</td>
<td>49.5</td>
</tr>
<tr>
<td>Swissair</td>
<td>Singapore Airlines (Singapore)</td>
<td>0.6</td>
</tr>
</tbody>
</table>


(Notes)

(a) Investor airlines in North America, Europe, Asia only.

(b) Air Canada sold a portion of its shares in Continental in May 1996 and has a plan to sell the remainder by 1997, subject to its shareholder approval.

(c) BA has an option to buy the rest of TAT by April 1997.
Table 2.3 lists changes in the number of the world's top-30 airline alliances during the last three years. The top-30 airlines were chosen according to rank of 1994 scheduled revenue passenger-kilometres. As of July 1996, Air France has formed the largest number of alliances among the top-30 carriers, forming 31 alliances, 13 of which involve equity investments. Air France is followed by Lufthansa, forming 26 alliances, among which it invested in four alliance partners. Malaysia Airlines and KLM follow the alliance race, forming 19 and 18 alliances, respectively. Those 'friendly' carriers listed in Table 2.3 account for more than 90 per cent of the total alliances in 1996.

**TABLE 2.3 The World's Top Airlines' Alliance Race**

<table>
<thead>
<tr>
<th>Airline</th>
<th>'96</th>
<th>'95</th>
<th>'94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air France</td>
<td>31 (13)</td>
<td>34 (13)</td>
<td>25 (12)</td>
</tr>
<tr>
<td>Lufthansa</td>
<td>26 (4)</td>
<td>25 (3)</td>
<td>25 (5)</td>
</tr>
<tr>
<td>Malaysia Airlines</td>
<td>19 (1)</td>
<td>19 (1)</td>
<td>17 (1)</td>
</tr>
<tr>
<td>KLM</td>
<td>18 (4)</td>
<td>14 (3)</td>
<td>10 (4)</td>
</tr>
<tr>
<td>Singapore Airlines</td>
<td>17 (3)</td>
<td>8 (3)</td>
<td>5 (3)</td>
</tr>
<tr>
<td>Air New Zealand</td>
<td>17 (2)</td>
<td>8 (2)</td>
<td>7 (2)</td>
</tr>
<tr>
<td>Swissair</td>
<td>16 (4)</td>
<td>9 (4)</td>
<td>9 (4)</td>
</tr>
<tr>
<td>Delta Airlines</td>
<td>15 (2)</td>
<td>13 (2)</td>
<td>14 (4)</td>
</tr>
<tr>
<td>Korean Air</td>
<td>15 (0)</td>
<td>14 (0)</td>
<td>12 (0)</td>
</tr>
<tr>
<td>Japan Airlines</td>
<td>14 (3)</td>
<td>10 (3)</td>
<td>9 (3)</td>
</tr>
<tr>
<td>British Airways</td>
<td>13 (5)</td>
<td>8 (5)</td>
<td>11 (5)</td>
</tr>
<tr>
<td>United Airlines</td>
<td>13 (0)</td>
<td>14 (0)</td>
<td>12 (0)</td>
</tr>
<tr>
<td>Air Canada</td>
<td>12 (2)</td>
<td>9 (1)</td>
<td>9 (1)</td>
</tr>
<tr>
<td>American Airlines</td>
<td>12 (1)</td>
<td>8 (1)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>Cathay Pacific</td>
<td>11 (2)</td>
<td>8 (2)</td>
<td>10 (1)</td>
</tr>
</tbody>
</table>

(Source) Airline Business (1994-96)

(Note) The number of equity investment alliances is shown in parenthesis.
### TABLE 2.3 (Continued)

<table>
<thead>
<tr>
<th></th>
<th>'96</th>
<th>'95</th>
<th>'94</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAS</td>
<td>11 (0)</td>
<td>9 (2)</td>
<td>9 (2)</td>
</tr>
<tr>
<td>Alitalia</td>
<td>10 (1)</td>
<td>7 (1)</td>
<td>9 (1)</td>
</tr>
<tr>
<td>Varig</td>
<td>10 (0)</td>
<td>12 (0)</td>
<td>11 (0)</td>
</tr>
<tr>
<td>Continental</td>
<td>9 (2)</td>
<td>5 (2)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>Canadian Airlines</td>
<td>9 (1)</td>
<td>8 (1)</td>
<td>5 (1)</td>
</tr>
<tr>
<td>Northwest Airlines</td>
<td>9 (1)</td>
<td>6 (1)</td>
<td>4 (1)</td>
</tr>
<tr>
<td>Qantas</td>
<td>8 (3)</td>
<td>7 (3)</td>
<td>7 (3)</td>
</tr>
<tr>
<td>Saudia</td>
<td>8 (0)</td>
<td>7 (0)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Philippine Air</td>
<td>7 (1)</td>
<td>6 (0)</td>
<td>6 (0)</td>
</tr>
<tr>
<td>Sabena</td>
<td>6 (1)</td>
<td>2 (1)</td>
<td>3 (1)</td>
</tr>
<tr>
<td>Virgin Atlantic</td>
<td>6 (0)</td>
<td>5 (0)</td>
<td>3 (0)</td>
</tr>
<tr>
<td>USAir</td>
<td>5 (3)</td>
<td>7 (1)</td>
<td>5 (0)</td>
</tr>
<tr>
<td>All Nippon Air</td>
<td>5 (2)</td>
<td>5 (2)</td>
<td>4 (2)</td>
</tr>
<tr>
<td>Thai Air</td>
<td>4 (0)</td>
<td>5 (0)</td>
<td>3 (0)</td>
</tr>
<tr>
<td>Aeroflot</td>
<td>4 (0)</td>
<td>4 (0)</td>
<td>4 (0)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>360 (60)</strong></td>
<td><strong>296 (57)</strong></td>
<td><strong>261 (55)</strong></td>
</tr>
</tbody>
</table>

(Source) Airline Business (1994-96)

(Note) The number of equity investment alliances is shown in parenthesis.
### TABLE 2.4 Strategic Alliances between Top-30 Airlines

<table>
<thead>
<tr>
<th></th>
<th>AA</th>
<th>AC</th>
<th>AF</th>
<th>AZ</th>
<th>BA</th>
<th>CO</th>
<th>CP</th>
<th>CX</th>
<th>DL</th>
<th>JL</th>
<th>KE</th>
<th>KL</th>
<th>LH</th>
<th>MH</th>
<th>NA</th>
<th>NW</th>
<th>NZ</th>
<th>PA</th>
<th>QF</th>
<th>RG</th>
<th>SK</th>
<th>SN</th>
<th>SQ</th>
<th>SR</th>
<th>TG</th>
<th>TW</th>
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<th>VS</th>
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<tbody>
<tr>
<td>AA</td>
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<tr>
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[Notes] v: Simple route-by-route alliance  x: Broad commercial alliance  o: Equity investment alliance
2.3.2 Areas of coordination

In order to identify areas of joint activities between partners and types of alliances, we investigate forty-six alliances between the top-30 airlines shown in Table 2.3. Table 2.4 shows these forty-six alliances. These alliances are categorized into three classes based on degree of coordination, which will be described below. Detailed descriptions are provided in Appendix A.

Based on analysis of the forty-six cases, areas of joint activities between partners are identified as: (1) coordination in ground handling; (2) joint use of ground facilities; (3) shared membership for frequent flyer programs (FFP); (4) codesharing or joint operations; (5) block space sales; (6) coordination of flight schedules; (7) exchange of flight attendants; (8) joint development of systems or systems softwares; (9) joint advertising and promotion; (10) joint maintenance; and (11) joint purchase of aircraft/fuel.

Alliance partners can share terminal facilities or move ground operations close to each other to carry out better ground handling. For example, Air Canada (AC)-Air France (AF) partners moved their ground operations in Paris and Toronto adjacent to each other. In some alliance cases, each partner performs ground handling at its respective home base.

Alliance partners can reduce costs by sharing ground facilities such as lounges, gates, and check-in counters. In many alliance cases, two partners link their FFPs to allow passengers carried by one partner to accumulate air miles on its partner's FFP.

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8 The areas of joint activities are roughly ordered on an increasing level of coordination. In general, relationship between alliance partners gets stronger as the areas of coordination are extended to higher levels of joint activities.
If two carriers make a block-space sales agreement, each carrier can purchase a block of seats in the other carrier's flights and resell them to passengers. For example, Air Canada and Korean Air signed such an agreement on the Seoul-Vancouver route, under which each buys 48 seats from the other's flights on the route. In some cases, only one partner can purchase a block of seats from the other partner on a specific route (e.g., Delta-Sabena alliance on New York-Brussels route).

Coordination of flight schedules as well as linkage of networks enables partners to create a large online service network that connects passengers between the partners' networks. Partners can re-schedule arrival and departure flights at connecting airports in a way that provides sufficient time for connections while minimizing waiting time between flights.

Areas of cooperation can be enlarged by exchanging flight attendants. In late 1993, BA wet-leased 3 USAir flights from Baltimore, Charlotte and Pittsburgh to London. BA used USAir pilots and crews who provided services in BA uniforms. Another example is where Alitalia wet-leased a Continental DC-10 aircraft on a codeshared Newark-Rome route.

The degree of integration is made much stronger by joint development of operations planning systems, pricing and yield management systems, and information technology systems. Some partners jointly promote and advertise. For example, KLM and Northwest (NW) share a "Worldwide Reliability" logo on the fuselages of their planes, tickets, advertising materials and in-flight service amenities. Some partners further integrate their operations in maintenance, purchasing and inventory (e.g., AC-Continental, BA-Qantas,
Delta-Singapore, and KLM-NW alliances).

### 2.3.3 Types of alliances

As shown in Tables 2.4 and 2.5, the forty-six alliances are classified into three categories according to the extent of coordination:

1. simple route-by-route alliance (28 cases);
2. broad commercial alliance (9 cases);
3. equity alliance (9 cases).

Table 2.5 shows the frequency of the joint activities undertaken between partners for each type.

The simple route-by-route alliances are the simplest form of alliances and involve a lower level of coordination (e.g. ground handling, joint use of ground facilities, codesharing and joint operations, block-space sales, coordination of flight schedules for directly related flights, etc.) on a few routes. Joint activities between partners for each of the 28 simple route-by-route alliances are summarized in Table 2.6. One example of this type of alliance is the KLM-Japan Airline (JL) alliance signed in January 1993. They have a codesharing agreement on the Tokyo-Amsterdam-Madrid and Tokyo-Amsterdam-Zurich routes where JL operates the Tokyo-Amsterdam leg of the routes and KLM operates Amsterdam-Madrid and Amsterdam-Zurich legs of the routes. As a result of the pact, JL could replace its non-stop flights on Tokyo-Madrid and Tokyo-Zurich by these codeshared flights and increase its flight frequency on the Tokyo-Amsterdam route.

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9 US GAO investigated 61 alliances between US and foreign carriers, as of December 1994. Based on the geographic scope of codesharing routes, US GAO categorized these 61 alliances into three groups: major strategic alliances (3 cases), regional alliances (8 cases), and point-specific alliances (50 cases). It is possible, however, for some alliance partners to have a somewhat stronger relationship even with a smaller number of alliance routes. Thus, it may be better to use a different criterion: the extent of coordination.
### TABLE 2.5 Degree of Coordination for Each Type of Alliance

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<th>Type 1 (a)</th>
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<td>Shared Frequent Flyer Programs</td>
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<td>Joint Maintenance</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(11%)</td>
</tr>
<tr>
<td>Joint Purchase of Aircraft/Fuel</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(44%)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>28</strong></td>
<td><strong>9</strong></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>

**Notes**
- (a) Type 1: Simple route-by-route alliances (28 cases), Type 2: Broad commercial alliances (9 cases), Type 3: Equity alliances (9 cases).
- (b) The number in the parenthesis is the percentage of a particular joint activity within the type of alliance.

TABLE 2.6 Joint Activities of Simple Route-by-Route Alliance Partners

|                           | AA | AA | AC | AC | AF | AF | AZ | CP | CP | CP | DL | DL | DL | JL | JL | JL | LH | MH | MH | MH | NA | NW | NJ | NZ | NZ | NZ | QF | SK | UA |
|---------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Coordinating ground handling | X  | X  | X  | X  | X  | X  |     |    |    |    |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Joint use of ground facilities | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| FFP partnership            | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| Codesharing                | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| Block Space Sales          | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| Coordination of Schedule   | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| Exchange of Flight Attendants | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| Development of Systems     | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| Joint Advertising          | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| Joint Purchase of Aircraft/Fuel | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |

TABLE 2.7 Joint Activities of Broad Commercial Alliance Partners

<table>
<thead>
<tr>
<th>Joint Activities</th>
<th>AC</th>
<th>LH</th>
<th>UA</th>
<th>CO</th>
<th>AZ</th>
<th>DL</th>
<th>VS</th>
<th>DL</th>
<th>SN</th>
<th>LH</th>
<th>UA</th>
<th>LH</th>
<th>TG</th>
<th>SK</th>
<th>SK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination in ground handling</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Joint use of ground facilities</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>FFP partnership</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Codesharing or Joint Operations</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Block Space Sales</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Coordination of flight schedules</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Exchange of flight attendants</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Joint development of systems</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Joint advertising and promotion</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Joint maintenance</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

(Note) X: joint activity between partners

## TABLE 2.8 Joint Activities of Equity Alliance Partners

<table>
<thead>
<tr>
<th>Joint Activities</th>
<th>AA</th>
<th>AC</th>
<th>BA</th>
<th>BA</th>
<th>DL</th>
<th>DL</th>
<th>KL</th>
<th>QF</th>
<th>SR</th>
<th>SQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination in ground handling</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Joint use of ground facilities</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>FFP partnership</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Codesharing or Joint Operations</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Block Space Sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination of flight schedules</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Exchange of flight attendants</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint development of systems</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Joint advertising and promotion</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Joint maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Joint Purchase of aircraft/fuel</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

(Note)  X: joint activity between partners

The broad commercial alliance is a more advanced form of alliance than the simple route-by-route alliance. As shown in Table 2.5, areas of coordination are extended to coordination of flight schedules, joint development of systems, and joint advertising and promotion. It involves collaboration between two carriers on more than a few routes. It usually involves feeding traffic to each other at hub airports. Table 2.7 shows joint activities for each of the 9 broad commercial alliances investigated. Among others, Delta Airlines (DL) and Virgin Atlantic (VS) signed a broad commercial agreement in April 1994. DL gained access to London Heathrow airport, which is a key gateway for trans-Atlantic flights, by buying 10-15 per cent of all seats on VS flights between London and various US cities on which both partners codeshare. Since this agreement also includes a FFP partnership, passengers flying VS can accumulate air miles to any of the worldwide destinations served by DL.

The equity alliance is the most advanced and durable form of alliance. As shown in Table 2.5, partners cooperate in almost all areas of joint activities. This is possible since they either invest in or exchange equity with their partners.\textsuperscript{10} It involves codesharing on a vast number of routes so as to strategically link both airlines' flight networks. Table 2.8 lists joint activities for each of the 9 equity alliances. One example is the KLM/NW alliance. KLM gets 25 per cent of NW's voting shares and 49 per cent of its equity. Since they received antitrust immunity from the US, they are able to achieve a high level of

\textsuperscript{10} Alliance partners' interests at some stage can conflict with each other. In this situation, alliances without an ownership bond are more likely to break up, as compared to those with equity investments. For example, United-BA and Lufthansa-American partnerships broke up in the early 1990s when the US partners in both alliances expanded their own operations in trans-Atlantic markets (Lobbenberg, 1994).
integration without fear of legal challenges from competitors. They can discuss market strategy and pricing. Another example is the alliance between American Airlines (AA) and Canadian Airlines International (CP) signed in April 1994. AA invested $190 million in CP for 25 per cent of CP’s voting shares and 8.33 per cent worth of its convertible preferred shares.

2.4 REASONS FOR ALLIANCE FORMATION

Why did so many alliances form in the early 1990s? Other than avoiding foreign ownership limits, bilateral restrictions, and cost constraints mentioned in Section 2.1, there may be economic and strategic reasons for airlines to form close partnerships with other airlines.

2.4.1 Network expansion by linking partner networks

There are demand factors which cause consumers to prefer airlines serving a large number of points to airlines serving a smaller number of points, with all other things such as air fares held constant (see footnote 1 in Chapter 1). In order to attract more passengers in a more competitive environment, airlines need to offer services to a wider range of destinations in the world.

Linking existing network to its partner’s network, each partner is able to expand the number of destinations. For example, Lufthansa (LH) and United (UA) have linked their networks since June 1994. As of December 1994, LH codeshared on UA flights serving 25 US cities beyond UA hubs, while UA codeshared on LH flights serving 30 European and
the Middle Eastern cities beyond LH hub. The carriers also codeshared on flights between UA and LH hubs. They were able to expand the number of destinations as a result of this partnership. Network expansion through other strategies, such as mergers and acquisitions, is currently constrained by foreign ownership laws and nationality clauses in bilateral air service agreements. Alliances may provide a mechanism to avoid some of these current restrictions.

Some alliances allow partners involved to access an attractive airport that it would otherwise be unable to access. For example, the current bilateral agreement between the US and UK specifies that only two US carriers (currently, American and United) have access to London Heathrow airport. It is a great disadvantage for other US carriers competing with these two US carriers in trans-Atlantic markets. However, the DL/VS partnership enables DL to advertise non-stop flights to London Heathrow from various US gateways, although DL does not actually fly these non-stop flights.

Some alliances enable a participating carrier to enter thin markets that it would not otherwise serve profitably on its own. For example, Qantas formed a codesharing alliance with Air Vanuatu on the Australia-Vanuatu route, as load factors would not be viable if it introduced its own aircraft onto the route (BTCE, 1996, p.12).

2.4.2 Increased traffic feed between partners

Successful linkage of alliance partner networks would allow partners to feed traffic to each other, and thus increase load factors on their flights without increasing flight
frequencies. For example, BA successfully linked its trans-Atlantic routes to USAir's domestic network after the two carriers formed an alliance in January 1993. According to the July 1994 issue of Official Airline Guides, USAir fed its domestic traffic, which originated from 38 US interior cities, to BA's trans-Atlantic flights to London through five US gateways: Boston, Baltimore/Washington, Los Angeles, New York, and Philadelphia. Thanks to USAir's traffic feed, during the 1993-1994 period, BA was able to increase its average load factor to 73.8 per cent from 72.4 per cent on those five trans-Atlantic routes.

In addition to traffic feed between partners, each partner may be able to increase "perceived" flight frequencies, although each does not increase actual flight frequency. For example, LH and UA both provided 31 non-stop flights on the Washington, D.C.-Frankfurt route in July 1993 (pre-alliance) and July 1994 (post-alliance). Thanks to the alliance, each partner was able to offer 62 non-stop flights because they were able to put their flight codes on their partner's flights.

### 2.4.3 Cost effectiveness through network expansion and joint operation

Network expansion and joint operation allows alliance partners to reduce cost through economies of scale, scope and traffic density. Economies of scale can be achieved if an alliance partner is able to serve the same amount of traffic at a lower cost, with its network size held constant. For example, joint advertising and promotion, joint purchase of fuel and aircraft, and joint handling of baggage transfer will result in economies of scale. Economies of scope can be achieved if alliance partners link their existing networks so that they can
provide connecting services for new markets. Carriers do not need to buy new aircraft but rather reschedule existing fleets to serve the new markets. Additional baggage handling or additional gates are not needed to serve the new markets. Economies of traffic density can be achieved if alliances allow partners involved to use more efficient, larger aircraft and/or to operate fixed ground facilities and personnel more intensively. Mutual traffic feed may allow the partners to switch to larger aircraft and operate this aircraft more intensively. Joint use of ground facilities and personnel also spreads the partners' fixed costs over more passengers.

2.4.4 Provision of higher quality of service

Passengers prefer online services to interline services since online services provide higher quality of service for connecting passengers. Close coordination and joint operations enable alliance partners to create a large, de facto, online service network for connecting passengers.

The partners coordinate flight schedules to minimize waiting times between flights while providing sufficient time for connections. Relocation of arrival gates close to departure gates reduces the time and effort required by passengers to make connections. Single check-in reduces the time necessary for passengers to re-check-in. Joint baggage handling eliminates the need to retrieve and recheck baggage at a connecting place, and thus reduces the risk associated with interline handling in which no carrier has sole responsibility for the baggage at the connecting place. In order to create these online service attributes,
alliance partners need to coordinate or share operations which may also allow the partners to reduce their average operating costs through more intensive use of shared facilities and personnel. Therefore, increasing quality of service and decreasing average operating costs are jointly achievable if partners collaborate very well.

Earlier work has found that a passenger's schedule delay time, defined as the difference between the passenger's desired departure and actual departure time, is one of the most important aspects of service quality (Morrison and Winston, 1986; and Winston, 1993). Chapter 4 examines the effects of four major alliances between US and European carriers on schedule delay time by using major trans-Atlantic routes for the 1990-94 period. It is found that schedule delay times are reduced by 12-25 per cent during the post-alliance period, depending on the route.

2.4.5 Increased itinerary choices for passengers

Passenger choices often increase since alliances allow partners to provide more alternatives to passengers. For example, consider a passenger who wants to fly from Indianapolis to Lyon. She can fly Indianapolis-Washington, D.C.-Frankfurt-Lyon on UA/LH partner flights. She can also fly Indianapolis-Pittsburgh-London-Lyon on BA/USAir partner flights. Alternatively, she can fly Indianapolis-Detroit-Amsterdam-Lyon on KLM/NW alliance flights. Without alliances, she would have to use interline flights on several different carriers, which are less convenient.
2.4.6 Competitive advantages on computer reservation system displays

Having formed codesharing alliances, alliance partners can obtain competitive advantages over non-aligned competitors on CRS displays. First, a codeshared non-stop flight is listed twice in CRSs in the US because two partners place their individual codes on the same flight. The number of listings for the same flight increases to three times when the flight is a one-stop flight. Second, codeshared connecting flights get listed ahead of interline flights on CRS screens. Multiple listings and priority displays push other airline services further down the screen or onto the next screen. Since travel agents tend to book most flights on the first screen of CRSs, airlines attempt to obtain the most advantageous position on CRS displays. The multiple listing and priority display of alliance flights is one of the most important strategic reasons for forming alliances.

Although there are six reasons for strategic alliance formation, this thesis does not deal with any CRS display issues arising from strategic alliances. However, in Chapters 3 and 4, the other five reasons (i.e., network expansion, increased traffic feed, cost

---

11 US travel agents, who book approximately 80 per cent of all flights in the US, generally use one of four CRSs: (i) Sabre (26% market share), which is owned by American Airlines' parent corporation; (ii) Appollo (30% market share), which is owned by a partnership consisting of United, USAir, BA, KLM, and other foreign airlines; (iii) Worldspan (15% market share), which is owned by Delta, Northwest, TWA, and some Asian airlines; and (iv) System One (9% market share), which is owned by an affiliate of Continental.

12 In Europe, a particular flight cannot be listed more than twice in the CRSs, but in the US, there are no controls over the number of times that a codeshare flight can appear (US GAO, 1995).

13 The triple listings occur because both partners in an alliance list flight segments under their own code and because CRSs also display a third listing as an interline flight. For example, consider a Lufthansa/United codeshared flight on the Chicago-Frankfurt-Berlin route where United (UA) serves the Chicago-Frankfurt leg and Lufthansa (LH) serves the Frankfurt-Berlin leg. This one-stop codeshared flight is listed three times on the CRSs as follows: (i) LH's connecting flight between Chicago and Berlin, (ii) UA's connecting flight between Chicago and Berlin, and (iii) a LH/UA's interline flight (For more detail, see US GAO, 1995, pp.53-59).
competitiveness, provision of higher quality of services, and increased itinerary choices) will be reflected in the analysis.

2.5 FUTURE EVOLUTION OF STRATEGIC ALLIANCES

Because of consumer preferences for airlines with extensive international networks, airlines will continue to extend their networks. Large network carriers are perceived by many consumers as providing a higher quality of service. Carriers throughout the world are extending their reach to larger and larger portions of the globe. The airline industry will eventually globalize (Tretheway and Oum, 1992, pp.103-104). Since there are a number of factors which will affect the globalization, it is almost impossible, at present, to precisely predict which airlines will be able to form future global airline networks. However, on the basis of previous discussions on alliance history, regulatory systems, and reasons for alliance formation, it may be possible to conjecture how future global airline networks will emerge. These conjectures are described below.

Global airline networks will not likely be formed by individual carriers, but by a group of airlines from each continent. The current alliance race will likely continue unless foreign ownership laws and nationality clauses in bilateral agreements change. The basic rationale behind this prediction is as follows: A mega carrier will continue to face severe difficulty establishing a global network through mergers and acquisitions. It will require tremendous funding to establish the carrier's global network, which may be beyond the carrier's financial resources (see footnote 2 in Chapter 1). Second, it is expected that some
regulatory constraints in international aviation markets will continue to exist in the future. Although international air transport services have been moving towards liberalization of bilateral agreements, it is unlikely that international markets will ever be deregulated to the same extent as intra-continental markets. ¹⁴ Third, it is expected that there will continue to exist legal, political, and institutional constraints on mergers and acquisitions between airlines of different nations. Many countries are still proud of having independent "national flag" carriers. Mergers or acquisitions of such airlines by foreign carriers would be politically unacceptable to domestic governments.

*Major strategic alliances will become more stable in that each partner will stick with one major strategic alliance group.* This can be supported by observing the direction of changes in some major strategic alliances during the past years. In the earlier stage of the alliance race, many carriers participated in the race simply because of the fears of being left behind (Airline Business 1995). Many carriers formed multiple alliances with different carriers, between which no alliance existed. For example, Lufthansa (LH) formed alliances with Canadian Airlines (CP) and United (UA) in 1989 and 1993, respectively. Air Canada (AC) formed a broad commercial alliance with UA in 1992, and invested in Continental (CO) in 1993. In the meantime, Austrian (OS), SAS (SK), and Swissair (SR) formed a trilateral European alliance in 1990, called European Quality Alliance (EQA). Furthermore, EQA carriers searched for a US carrier as their partner. SR already had formed an alliance with Delta (DL), and SK with CO.

¹⁴ Major airlines in North America, Europe and Asia have been engaged in extending their networks in order to cover the entire continental markets. See the excellent discussion in Oum and Taylor (1995).
Chapter 2. The History, Current Status and Future Evolution

Recent major adjustments associated with these alliances have occurred. LH formed a trilateral alliance with UA and Thai Airways (TG), and signed new agreements with SK in 1995 and AC in March 1996, resulting in a multilateral LH-UA-AC-TG-SK alliance. The LH-SK linkup led SK to withdraw from EQA and discontinue with CO, while this linkup guided SK to form an alliance with UA in April 1996. Immediately after forming the LH-AC alliance, AC announced its plan to fully dispose of its stake in CO by early 1997 and LH cancelled its cooperation with CP in order to strengthen its relation with AC.

Meanwhile, another multilateral alliance, DL-SR-SQ-SN-OS, has developed. SR purchased about a 49 per cent stake in Sabena (SN), bringing SN into its alliance with DL, OS and Singapore Airlines (SQ). The DL-SR-SN-OS alliance recently received antitrust immunity from the US DOT so that the partners are now able to achieve a higher level of integration.\(^\text{15}\)

*\textit{A limited number of future global airline networks will be formed by strategic alliances of airlines from each continent.} Because of the enormous size of the US market, each alliance would include a major US carrier. Each alliance would also include one major European carrier and/or one major Asian carrier because of substantial traffic flows between North America and these two continents.\(^\text{16}\) These anchor carriers will provide long-haul intercontinental services, while other junior partners on each continent will provide feeder

\(^{15}\) Cross-ownerships among these partners are as follows: DL and SR mutually exchanged about 5 per cent of their voting stock; SR holds a 10 per cent equity stake in OS and about 49 per cent of voting stock in SN.

\(^{16}\) Traffic between North America and Europe, and Asia account for 12.6 per cent, the largest, and 6.4 per cent, the second largest, of total inter-continental scheduled passengers, respectively. Together with international traffic within North America, Europe and Asia, international traffic flows involving these three continents account for about 71 per cent of the total international scheduled passengers (IATA, 1994).
services to hubs of their global network.

Current major alliances can be represented by (i) AA-CP, (ii) BA-USAir, (iii) DL-SR-SQ-SN-OS, (iv) LH-UA-AC-TG-SK, and (v) KLM-NW. Among other major carriers, Air France, CO and JL have yet to participate in global alliances. Although participation of these major carriers may increase the number of global airline networks, global networks will be likely formed by these five strategic alliance groups since they will continue to extend their alliance networks.\(^\text{17}\) The first alliance carriers to successfully form a global network will reap the greatest benefits. The carriers left behind will likely lose market share, eventually being at most feeder carriers to global airline networks.

## 2.6 SUMMARY

Much news associated with strategic alliances in the aviation industry has appeared in the popular press such as newspapers, industry magazines and other sources. Nevertheless, it is difficult for even those who closely follow the industry to understand the whole picture of strategic airline alliances.

This chapter provides general information on the history and current status of alliances, and conjectures the role of alliances in the formation of future global networks. In general, the US and European governments have supported strategic alliances as a means of facilitating competition among multinational airline networks. As a result, more than 50

\(^{17}\) Based on early observations of airline globalization, Oum and Taylor (1995) also predict that successful global networks will arise through strong alliances between major carriers, supported by smaller regional feeder carriers.
strategic alliances emerged yearly during the 1990s.

Based on a study of the forty-six alliances among the world's top-30 airlines, the areas of joint activities are identified. We find that the degree of integration gets stronger in alliances involving equity investment, as compared to alliances without equity investment. Equity investments increase partner commitments. Various economic and strategic incentives for airlines to join strategic alliances are recognized. Chapters 3 and 4 will reflect these incentives excluding the advantages of CRS displays.

We conjecture that strategic alliances will continue to expand and form global airline networks. We also expect that the present alliance race will continue and major strategic alliances will become more stable. Consequently, a limited number of future global networks will likely be formed by strategic alliances of airlines from each continent.
CHAPTER 3. MODELS OF STRATEGIC ALLIANCES

3.1 INTRODUCTION

Despite the growing importance of international airline alliances, few researchers have devoted effort to constructing formal models of the alliances.\(^1\) This chapter constructs formal models to examine the effects on market outcomes and economic welfare of different types of alliances: "complementary" and "parallel" alliances.

The "complementary" alliance refers to the case where two firms link their existing networks and build a new complementary network in order to feed traffic to each other. For example, KLM and Northwest signed a "complementary" alliance by which they were able to connect 88 US cities to 30 European and the Middle Eastern cities via Northwest's hubs (Boston, Detroit, and Minneapolis) and KLM's Amsterdam hub, as of December 1994 (US GAO, 1995).

The "parallel" alliance refers to collaboration between two firms competing on the same routes. After the alliance, the two firms coordinate and/or integrate their operations on these routes. Two types of parallel alliances are considered in this chapter: "no shut-down" and "shut-down" parallel alliances. Each partner continues to individually provide non-stop services on an alliance route in the first type, while two partners integrate their

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\(^1\) The effects of alliances have been empirically investigated by a few studies including Youssef and Hansen (1994), Gellman Research Associates (1994), and Oum, Park and Zhang (1996).
non-stop services on the route in the second type. For example, Air Canada and Korean Air implemented a "no shut-down" parallel alliance on the Seoul-Vancouver route. Delta and Sabena formed a "shut-down" parallel alliance on the New York-Brussels route where Delta discontinued flights and purchased a block of seats from Sabena.

More specifically, Chapter 3 investigates the following questions: After alliance partners form a particular type of alliance in a specific market, what happens to the partners' and non-aligned competitors' outputs in that market and other markets? How are profits of the partners and non-partner affected by the alliance? What happens to total output and air fares in that market and other markets? Under which conditions does each of the alliances improve economic welfare?

In the next section, the Basic Model is considered so as to compare pre-alliance, complementary alliance, and parallel alliances situations. Section 3.3 examines the effects of a complementary alliance on market outcomes and total welfare. Section 3.4 investigates the effects of the two types of parallel alliances on the partners' outputs and total welfare. Section 3.5 provides the Extended Model by relaxing some conditions assumed in the Basic Model. Section 3.6 tests some testable predictions associated with the effects on firms' outputs and total output. Finally, major findings of this chapter are summarized in Section 3.7.

3.2 THE BASIC MODEL

3.2.1 The pre-alliance situation as a benchmark
Chapter 3. Models of Strategic Alliances

We need to begin by first constructing a pre-alliance situation where no airlines have yet formed any type of alliance. As depicted in Figure 3.1, a network is considered, consisting of three gateway cities located in different countries: A, B and H. There are three origin and destination markets, AH, BH and AB, and three firms are operating in the network. Firm 1 is assumed to serve all three markets (AH, BH and AB) using its hub-and-spoke network. Firms 2 and 3 are assumed to serve AH and BH markets, respectively.

![Figure 3.1 A Simple Air Transport Network](image)

If travellers want to fly from city A and arrive at city B by firm 1's airplanes, they

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2 In reality, complementary alliance partners compete with a non-partner's connecting service by linking their hubs, not through the non-partner's hub. A slightly different network structure from the network in Figure 3.1 may be more realistic. However, the change in the network structure does not really matter. More importantly, the network in Figure 3.1 is very realistic for the parallel alliance type. Using the same network can control a network-structure effect in examining the effects of different strategic alliances.

3 Note that two national carriers are assumed to operate on each route of the network. Since international air services between two cities are mainly decided by bilateral agreements between the two countries involving the two cities, this assumption seems to be reasonable.
must change airplanes at the hub airport H.\textsuperscript{4} Or, they can use two segment flights, separately provided by firms 2 and 3, in order to arrive at their final destination. However, it is assumed that in the pre-alliance situation, travellers do not use multiple carriers' interline connecting services because of poor connections between firms 2 and 3.\textsuperscript{5}

\textbf{3.2.2 The complementary alliance situation}

Consider a situation where firms 2 and 3 form a "complementary" alliance. Both firms jointly provide connecting services for passengers flying between cities A and B, while continuing to provide non-stop services as before. To compete with firm 1's connecting services, the partners enhance quality of their connecting services. For example, the partners can adjust flight schedules to minimize waiting time between flights while providing enough time for connections. They can also re-locate departure gates for connecting flights close to arrival gates, coordinate baggage transfer, and cooperate other joint activities at the connecting airport. They agree to share revenues and costs from the connecting services.

To examine the effects of this alliance, we need to consider demands and costs. The "full" price demand model is considered from the viewpoint that each firm's demand in each

\textsuperscript{4} In Figure 3.1, the solid line indicates a non-stop route, while the dotted line symbolizes a connecting route. Assuming there is no non-stop service on the A-B route, we can introduce network complementarity between non-stop and connecting services, which is one of the important aspects of strategic alliances. This assumption also simplifies the analysis below. Of course, we can eliminate this assumption by introducing more carriers, say carriers 4 and 5, and assuming non-stop services on the A-B route by these carriers. However, this introduction does not change the propositions below.

\textsuperscript{5} If connections must be made at connecting airports or hubs, less of a traveller's time will be required with a single airline than when the trip involves switching airlines, because a single airline's connecting flights are more likely to reduce waiting time at the connecting airports and because there is a lower probability of baggage being lost with a single airline.
market depends not only on its air fare, but also on its service quality (De Vany, 1974; Panzar, 1979). Assuming that consumers can place a dollar value on service quality, each firm's demand in each market in the complementary alliance situation may be written as

\[ Q_{i}^{k} = D_{i}^{k}(\rho_{i}^{k}, \rho_{i}^{k}) \text{ for } i=1,2, i \neq j \]

\[ Q_{i}^{k} = D_{i}^{k}(\rho_{i}^{k}, \rho_{i}^{k}) \text{ for } i=1,3, i \neq j \]

\[ Q_{i}^{k} = D_{i}^{k}(\rho_{i}^{k}, \rho_{i}^{k}) \text{ for } i=1,2+3, i \neq j \]

where \( \rho_{i}^{k} \) is the full price of using carrier i's service in market k, which is the sum of air fare, denoted by \( p_{i}^{k} \), and the cost associated with the quality of i's service. \( \rho_{i}^{k} \) may be regarded as a quality-adjusted price.\(^6\) Solving the demand functions for \( \rho_{i}^{k} \) may yield the following inverse demand functions:

\[ \rho_{i}^{k} = d_{i}^{k}(Q_{i}^{k}, Q_{j}^{k}) \text{ for } k=AH, BH, AB, i \neq j. \]

We assume that outputs of rival carriers are substitutes in each city-pair market:

\[
\frac{\partial d_{i}^{k}}{\partial Q_{i}^{k}} < 0, \text{ for } k=AH, BH, AB, i \neq j. \quad (3.1)
\]

Two different costs of service quality are considered in this chapter: (i) schedule

\(^{6}\) The higher the air fare, the higher the "full" price. For a given fare, the higher the cost of service quality (i.e., the lower the quality of service), the higher the "full" price. Therefore, if carriers charge the same air fare in a market, then consumers prefer an airline serving the best service quality in that market.
Chapter 3. Models of Strategic Alliances

delay cost on each route, and (ii) inconvenience cost arising at the connecting airport.

The schedule delay cost is a passenger's schedule delay time arising from the difference between the passenger's desired departure and actual departure time. Research has found that the schedule delay cost depends largely on the carrier's flight frequency, which in turn depends on its total traffic (e.g., Douglas and Miller, 1974). Thus, if $Q'$ is the total passengers carried by carrier $i$ on route $k$, then the schedule delay cost may be written as $g'_k(Q'^i)$. It is assumed that $g'(\cdot)<0$, that is, the schedule delay cost of an airline declines with its traffic on the route. The schedule delay cost for the non-stop services is $g'_k(Q'_k + Q'_{AB})$ for $k = AH$ and $BH$, while the schedule delay cost for the connecting services is the sum of the schedule delay cost on each of the two local (non-stop) routes, $g'_{AH}(Q'_{AH} + Q'_{AB}) + g'_{BH}(Q'_{BH} + Q'_{AB})$.

The second component of the cost of service quality is a passenger's inconvenience cost due to connections. Carlton, Landes and Posner (1980) estimate that travellers incur an implicit cost of $13-17 (in 1978 dollars)$ for a single carrier's one-stop connecting services, as compared to its non-stop services. This extra cost for alliance partners' connecting services will be even larger, if the partners' connecting service is inferior to the single carrier's connecting service. For convenience of analysis, without loss of generality, we assume that the inconvenience cost for the single carrier's connections is zero, but that

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7 According to the consumer price index (CPI), the value of US$13-17 in 1978 can correspond to that of US$30.3-39.6 in 1995. The CPI can be collected from the IMF's International Financial Statistics.
for the partners' connections, denoted by $\gamma$, is positive. However, the partners' connecting cost will decrease as the level of their coordination increases at the airport $H$.

Carrier $i$'s production cost function on route $k$ may be expressed as $C_k(Q')$, implying its round-trip cost of carrying $Q'$ passengers on the route. Note that $Q'$ represents total passengers carried by the airline on the route. This production cost function reflects economies of traffic density, satisfying $C_k'(Q') > 0$ and $C_k''(Q') < 0$.\(^8\)

Given these demand and cost specifications, the profit function for the non-aligned carrier and aligned partners can be expressed as:

\[
\Pi^c = Q_{AH}^1 [d_{AH}(Q_{AH}^1, Q_{AH}^2) - S_{AH}(Q_{AH}^1 + Q_{AB}^1)] + Q_{BH}^1 [d_{BH}(Q_{BH}^1, Q_{BH}^3) - S_{BH}(Q_{BH}^1 + Q_{AB}^1)]
\]

\[
+ Q_{AB}^1 [d_{AB}(Q_{AB}^1, Q_{AB}^{(2+3)}) - S_{AB}(Q_{AB}^1 + Q_{AB}^1)]
\]

\[
- C_{AH}(Q_{AH}^1 + Q_{AB}^1) - C_{BH}(Q_{BH}^1 + Q_{AB}^1)
\]

\[
\Pi^{(2+3)c} = Q_{AH}^2 [d_{AH}(Q_{AH}^1, Q_{AH}^2) - S_{AH}(Q_{AH}^2 + Q_{AB}^{(2+3)})] + Q_{BH}^3 [d_{BH}(Q_{BH}^1, Q_{BH}^3) - S_{BH}(Q_{BH}^3 + Q_{AB}^{(2+3)})]
\]

\[
+ Q_{AB}^1 [d_{AB}(Q_{AB}^{(2+3)}, Q_{AB}^{(2+3)}) - S_{AB}(Q_{AB}^{(2+3)} + Q_{AB}^{(2+3)}) - \gamma]
\]

\[
- C_{AH}(Q_{AH}^2 + Q_{AB}^{(2+3)}) - C_{BH}(Q_{BH}^3 + Q_{AB}^{(2+3)})
\]

where superscript $c$ stands for complementary alliance.

---

\(^8\) Caves, Christensen and Tretheway (1984) distinguish between economies of traffic density and economies of firm size. Economies of traffic density mean that output is expanded by increasing flight frequency within a given network. Economies of firm size imply that output is expanded by adding points to the network. Many studies reach a common conclusion: roughly constant returns to firm size exist, while sizeable economies of traffic density exist up to fairly large volumes of traffic (See, for example, Caves, Christensen, Tretheway and Windle, 1987; and Brueckner and Spiller, 1994).
It can be shown that \( \frac{\partial^2 \pi^c_i}{\partial Q^i_{AH} \partial Q^i_{BH}} = 0 \). This implies that there are no network complementarities between the two local services. We can also show that

\[
\frac{\partial^2 \pi^c_i}{\partial Q^i_k \partial Q^i_{AB}} = -2g_k''(\cdot) - g_k''(\cdot) \cdot (Q^i_k + Q^i_{AB}) - C_k''(\cdot), \quad k = AH, BH. \tag{3.4}
\]

In (3.4), the first term is positive because an airline's schedule delay cost decreases with its traffic. The second term is positive if \( g \) is linear or concave. The third term is also positive because of economies of traffic density. (3.4) can be positive even if \( g \) is convex. More generally, it is assumed that (3.4) is positive, implying that there exist network complementarities between local and connecting services. In other words, a carrier's marginal profit from a local service increases as its connecting passengers increase.

In (3.1), outputs of rival carriers are assumed to be substitutes in each city-pair market. We further assume that in each market, a carrier's marginal profit decreases as the output of the competitor increases:

\[
\frac{\partial^2 \pi^c_i}{\partial Q^i_k \partial Q^i_{i'}} < 0, \quad k = AH, BH, AB, \quad i \neq j, \tag{3.5}
\]

which implies that within each market the outputs of duopolists are "strategic substitutes" in the terms of Bulow, Geanakoplos and Klemperer (1985).

### 3.2.3 The parallel alliance situation

Next, consider another post-alliance situation where firms 1 and 2 form a "parallel"
alliance in the sense that they were competitors in the AH segment of the network pre-alliance, but post-alliance, they coordinate and/or integrate their operations on that segment. For the convenience of notation, among the parallel alliance partners, firm 1 is called the hub partner, and firm 2 the non-hub partner. Firm 3 is called the non-partner.

Two types of parallel alliances are considered. The first type is where each of the two partners continues to individually provide local services in the AH segment and chooses its quantity to maximize joint profits. For example, Air Canada and Korean Air have implemented this type of parallel alliance on the Seoul-Vancouver-Toronto route since 1993.

The second type is where the two partners integrate local services in the AH segment in a way that the hub partner continues to provide local services, but the non-hub partner stops producing local services. For simplicity of analysis, it is assumed that the two partners equally share revenues and costs arising from the joint local operations. For example, Delta and Sabena formed this sort of parallel alliance on the New York-Brussels route where Delta stopped providing non-stop services after forming the alliance.

---

9 In Figure 3.1, firm 1 operates a hub-and-spoke network, while firm 2 does not. In practice, it is often difficult to distinguish between the hub partner and the non-hub partner because the alliance partners usually link their respective hubs (e.g., Brussels is Sabena's main hub and New York is Delta's). However, it is possible to distinguish between the hub partner and the non-hub partner in some cases. For example, Air Canada can be regarded as the hub partner and Korean Air as the non-hub partner on the Seoul-Vancouver-Toronto route.

10 Invariably, "shut-down" parallel alliances occur because both partners exchange two or more shut-down routes. For example, after forming the Delta/Sabena alliance, Delta shut down the New York-Brussels route in exchange for Delta serving the Atlanta-Brussels route exclusively. After forming the Northwest/Asiana alliance, Northwest shut down the Seoul-Seattle route in exchange for Northwest serving the Seoul-Detroit route exclusively. A "shut-down" parallel alliance would not occur if there is no opportunity for both partners to exchange shut-down routes. The exchange of shut-down routes is not treated in the theoretical models in this chapter.
Since the non-hub partner shuts down its operation in the second case, the first case is referred to as the "no shut-down" parallel alliance,\(^\text{11}\) the second as the "shut-down" parallel alliance, hereafter. In both cases, firm 3 operates alone in the BH segment as before. 

For consistency of analysis, we consider the same demand and cost specifications as those in the complementary alliance. In particular, by using the "full" price demand specification, inverse demand functions for the parallel alliance may be written as 

\[
\rho^i_{AB} = d^i_{AB}(Q^i_{AB}), \quad \text{for } i=1,2, \quad i \neq j
\]

\[
\rho^i_{BH} = d^i_{BH}(Q^i_{BH}), \quad \text{for } i=1,3, \quad i \neq j
\]

\[
\rho^i_{AH} = d^i_{AH}(Q^i_{AH})
\]

where \(\rho^i_k = p^i_k + g^i_k(\cdot)\), \(Q^2_{AH}\) is positive for the "no shut-down" case, and \(Q^2_{AH}\) is zero for the "shut-down" case. It is still assumed that conditions (3.1), (3.4) and (3.5) hold.

3.3 EFFECTS OF COMPLEMENTARY ALLIANCE

3.3.1 Effects on firms' outputs and profits

Let us first analyze the effects of the complementary alliance. We consider an

\(^{11}\) Although cost advantages due to economies of traffic density favours the "shut-down" type of parallel alliance over the "no shut-down" type, the latter is more prevalent than the former in reality. This is most likely to be related to factors not included in the theoretical models in this chapter. For example, many carriers believe that there is a long run value of maintaining their presence in major foreign cities. If a carrier has its partner drop out of an alliance route, it will cost the partner a lot to reestablish its services on that route. This is one of the reasons why many foreign carriers operate on some routes involving US cities while losing money on these routes.
equilibrium that arises when the non-aligned carrier (i.e., firm 1) and the aligned partners (i.e., firms 2 + 3) play a Cournot game in each market of the network.\textsuperscript{12} By using vectors $Q^1$ and $Q^2$, (2) and (3) can be simplified as
\begin{equation}
\max_{Q^1} \Pi^{1c} = \Pi^{1c}(Q^1, Q^2) \tag{3.6}
\end{equation}
\begin{equation}
\max_{Q^2} \Pi^{2c} = \Pi^{2c}(Q^1, Q^2, \gamma) \tag{3.7}
\end{equation}
where $Q^i = (Q_{Ah}^i, Q_{bh}^i, Q_{ab}^i)$ for $i = 1, 2$. For convenience of notation, superscript $2+3$ is replaced by 2. Assume that there exists a "stable" Cournot-Nash equilibrium $(Q^1(\gamma), Q^2(\gamma))$ which satisfies the following first-order conditions for maximization of (3.6) and (3.7):\textsuperscript{13}
\begin{equation}
\Pi^{1c}_1(Q^1(\gamma), Q^2(\gamma)) = 0 \tag{3.8}
\end{equation}
\begin{equation}
\Pi^{2c}_2(Q^1(\gamma), Q^2(\gamma); \gamma) = 0. \tag{3.9}
\end{equation}
Assume that the second-order conditions are also satisfied, i.e., the following Hessian

\textsuperscript{12} The Cournot assumption is not crucial in the duopoly market. Brander and Zhang (1990) and Oum, Zhang and Zhang (1993), using conjectural variations, find some evidence that airlines in duopoly markets behave like Cournot competitors.

\textsuperscript{13} This stability assumption is important. If an equilibrium is not stable, then a slight deviation by one player does not cause the equilibrium to return to that point. The stability of Cournot-Nash equilibrium has been studied by, among others, Hahn (1962), Seade (1980), Dixit (1986), Slade (1994), and Zhang and Zhang (1996). In particular, Zhang and Zhang (1996) extend single-market conditions for stability of Cournot-Nash equilibria to multimarket conditions.
matrices are negative definite for $i = 1, 2$:

\[
\begin{bmatrix}
\Pi^{ic}_{AH,AH} & \Pi^{ic}_{AH,BH} & \Pi^{ic}_{AH,AB} \\
\Pi^{ic}_{BH,AH} & \Pi^{ic}_{BH,BH} & \Pi^{ic}_{BH,AB} \\
\Pi^{ic}_{AB,AH} & \Pi^{ic}_{AB,BH} & \Pi^{ic}_{AB,AB}
\end{bmatrix}
\]

With the present specifications, it can be shown that as compared to the pre-alliance situation, firm 1 (the partners, respectively) produces less (more, respectively) output not only in the market where the complementary alliance occurs, but also in the other markets.

**Proposition 3-1.** Under a complementary alliance, firm 1 produces less outputs in markets AH, BH and AB, but the alliance partners produce more outputs in both their local market and the AB market than under the pre-alliance.

**Proof.** Differentiating (3.8) and (3.9) with respect to $\gamma$ yields

\[
\Pi^{ic}_{11} \frac{dQ^1}{d\gamma} + \Pi^{ic}_{12} \frac{dQ^2}{d\gamma} = 0,
\]

\[
\Pi^{ic}_{21} \frac{dQ^1}{d\gamma} + \Pi^{ic}_{22} \frac{dQ^2}{d\gamma} + \Pi^{ic}_{23} = 0
\]

where $\Pi^{ic}_{23} = [0, 0, -1]^T$. $[\cdot]^T$ denotes a transposed vector. Solving (3.10) and (3.11) for $(dQ^1/d\gamma, dQ^2/d\gamma)$, we have
\[ \frac{dQ^1}{d\gamma} = \left[ I - \left( \Pi_{11}^{lc} \right)^{-1} \Pi_{12}^{lc} \left( \Pi_{22}^{2c} \right)^{-1} \Pi_{21}^{2c} \right]^{-1} \left( \Pi_{11}^{lc} \right)^{-1} \Pi_{12}^{lc} \left( \Pi_{22}^{2c} \right)^{-1} \Pi_{21}^{2c} \]  

(3.12)

\[ \frac{dQ^2}{d\gamma} = -\left[ I - \left( \Pi_{22}^{2c} \right)^{-1} \Pi_{21}^{2c} \left( \Pi_{11}^{lc} \right)^{-1} \Pi_{12}^{lc} \right]^{-1} \left( \Pi_{22}^{2c} \right)^{-1} \Pi_{21}^{2c}. \]  

(3.13)

Differentiating (3.8) with respect to \( Q^2 \) yields the following 3-by-3 "derivative" matrix of carrier 1's reaction functions:

\[ R_2^{lc} = \frac{\partial R^{lc}(Q^2)}{\partial Q^2} = -\left( \Pi_{11}^{lc} \right)^{-1} \Pi_{12}^{lc} \] where \( R^{lc}(Q^2(\cdot)) \) is carrier 1's reaction function for the aligned partners' outputs. Similarly, a "derivative" matrix of the partners' reaction functions for firm 1's outputs can be defined as

\[ R_1^{2c} = \frac{\partial R^{2c}(Q^1)}{\partial Q^1} = -\left( \Pi_{22}^{2c} \right)^{-1} \Pi_{21}^{2c}. \]

In what follows, we show that every element of \( R_2^{lc} \) and \( R_1^{2c} \) matrices is negative:

First, it turns out that both Hessian inverse matrices are negative matrices. \( \left( \Pi_{11}^{lc} \right)^{-1} \) can be expressed as

\[
\frac{1}{|\Pi_{11}^{lc}|} \begin{bmatrix}
\Pi_{BH,BH}^{1c} & \Pi_{AB,AB}^{1c} & \left( \Pi_{BH,AB}^{1c} \right)^2 & \Pi_{AH,AB}^{1c} & \Pi_{BH,AB}^{1c} & -\Pi_{AH,AB}^{1c} & \Pi_{BH,BH}^{1c} \\
\Pi_{AB,AB}^{1c} & \Pi_{HH,HH}^{1c} & \Pi_{BH,AB}^{1c} & \Pi_{AH,AB}^{1c} & \Pi_{AB,AB}^{1c} & -\Pi_{AH,AB}^{1c} & \Pi_{BH,AB}^{1c} \\
-\Pi_{AH,AB}^{1c} & \Pi_{BH,AB}^{1c} & \Pi_{AH,AB}^{1c} & \Pi_{BH,AB}^{1c} & \Pi_{AB,AB}^{1c} & -\Pi_{AH,AB}^{1c} & \Pi_{BH,AB}^{1c} \\
\end{bmatrix}
\]

By the second-order conditions and the network complementarities conditions (3.4), every element of \( \left( \Pi_{11}^{lc} \right)^{-1} \) is negative. Similarly, \( \left( \Pi_{22}^{2c} \right)^{-1} \) is also a negative matrix. Second, \( \Pi_{12}^{lc} \) and \( \Pi_{21}^{2c} \)
are negative diagonal matrices because of the strategic substitutes condition (3.5). Thus, both $R_2^{1c}$ and $R_1^{2c}$ are negative matrices.

By using $R_2^{1c}$ and $R_1^{2c}$, (3.12) and (3.13) can be rewritten as

$$\frac{dQ_1}{d\gamma} = -[(I - R_2^{1c} R_1^{2c})^{-1} R_2^{1c} \Pi_{22}^{2c}]^{-1} \Pi_{22}^{2c}$$

(3.14)

$$\frac{dQ_2}{d\gamma} = -[(I - R_1^{2c} R_2^{1c})^{-1} \Pi_{22}^{2c}]^{-1} \Pi_{22}^{2c}.$$

(3.15)

The stability of Cournot-Nash equilibrium implies that the magnitude of the eigenvalues of matrices $R_2^{1c} R_1^{2c}$ and $R_1^{2c} R_2^{1c}$, must be less than one (Zhang and Zhang, 1996). Hence, by the Neumann lemma, $\left( I - R_2^{1c} R_1^{2c} \right)^{-1}$ and $\left( I - R_1^{2c} R_2^{1c} \right)^{-1}$ exists and

$$\left( I - R_i^{jc} R_j^{ic} \right)^{-1} = I + (R_j^{jc} R_i^{ic}) + (R_j^{jc} R_i^{ic})^2 + \cdots + (R_j^{jc} R_i^{ic})^n + \cdots$$

for $i = 1, 2$, $i \neq j$.

Since $R_j^{jc} R_i^{ic}$ is a positive matrix, then $\left( I - R_j^{jc} R_i^{ic} \right)^{-1}$ is also a positive matrix.

Therefore, $dQ_1/d\gamma > 0$ and $dQ_2/d\gamma < 0$ since $R_2^{1c}$ is a negative matrix and $\Pi_{22}^{2c}$ is a negative vector.

Q.E.D.

The intuitive explanation for Proposition 3-1 is as follows: If the partners provide

---

14 The Neumann lemma is that if $R$ is a real square matrix and the magnitude of eigenvalues of $R$ is less than one, then $(I - R)^{-1}$ exists and $(I - R)^{-1} = \sum_{i=0}^{\infty} R^i$. See, for example, Ortega and Rheinboldt (1970, p.45).
better quality of connecting services in market AB, the inconvenience cost \((\gamma)\) will decrease, which in turn increases connecting traffic for the partners, that is, \(dQ_{AB}^{2+3}/d\gamma < 0\). This connecting traffic increase implies that the partners can feed more traffic to each other. As a result, schedule delay costs for local non-stop services will decrease (i.e., service quality for the local services increases) and average operating costs on the AH and BH routes will decrease due to economies of traffic density. Consequently, increases in \(Q_{AB}^{2+3}\) lead to decreases in the partners' air fares in the AH and BH markets, which in turn increases AH and BH traffic as well. Therefore, it is possible that increasing quality of services and decreasing average operating costs are jointly achievable if the partners collaborate very well.

On the other hand, increases in \(Q_{AB}^{2+3}\) due to the better coordination decrease \(Q_{AB}^1\), resulting in increased carrier 1's unit costs on the AH and BH routes and increased schedule delay cost for its local services. As a result of the complementary alliance, carrier 1 decreases output not only in the AB market, but also in the other market.

Although firm 1 reduces output in markets AH, BH, and AB, it does not necessarily imply that it decreases profit, because profit is affected not only by outputs in these markets, but also by corresponding air fares. Thus, it is worthwhile to investigate whether each firm's profit increases or decreases due to the complementary alliance.

**Proposition 3-2.** Under a complementary alliance, firm 1 earns less profit, but the alliance
partners earn greater profit, as compared to the pre-alliance.

Proof. Substituting the Cournot-Nash equilibrium \((Q_1(y), Q_2(y))\) into (3.6) and (3.7), and differentiating these equations with respect to \(y\), we have

\[
\frac{\partial \Pi^{1c}}{\partial y} = \sum_{k=AH}^{AB} \frac{\partial \Pi^{1c}}{\partial Q_k^1} dQ_k^1 + \sum_{k=AH}^{AB} \frac{\partial \Pi^{1c}}{\partial Q_k^2} dQ_k^2 = \sum_{k=AH}^{AB} \frac{\partial d_k^1}{\partial y} dQ_k^2 Q_k^1
\] (3.16)

\[
\frac{\partial \Pi^{2c}}{\partial y} = \sum_{k=AH}^{AB} \frac{\partial \Pi^{2c}}{\partial Q_k^2} dQ_k^2 + \sum_{k=AH}^{AB} \frac{\partial \Pi^{2c}}{\partial Q_k^1} dQ_k^1 + \frac{\partial \Pi^{2c}}{\partial y} = \sum_{k=AH}^{AB} \frac{\partial d_k^2}{\partial y} dQ_k^1 Q_k^2 - Q_{AB}^2.
\] (3.17)

By the first-order conditions, the first term of the right-hand side of the first equations of (3.16) and (3.17) disappears. By condition (3.1), we have \(\frac{\partial \Pi^{1c}}{\partial y} > 0\) and \(\frac{\partial \Pi^{2c}}{\partial y} < 0\).

Q.E.D.

3.3.2 Effects on market outcomes and economic welfare

According to Proposition 3-1, it is not clear whether total output in each market increases or decreases due to the complementary alliance since firm 1 decreases output in each market, while the aligned partners increase. In this subsection, we examine the effects of the complementary alliance on total output and consumer surplus in each market, and total welfare.

In order to examine changes in total output due to the complementary alliance, we
further assume that the aligned partners and non-aligned competitors are symmetric.\textsuperscript{15} We can then show that total output in each market increases due to the complementary alliance.

**Proposition 3-3.** For the symmetric case, the complementary alliance results in (i) increased total outputs and (ii) decreased "full" prices in markets AH, BH, and AB. Therefore, consumers in these markets are better off due to the complementary alliance.

**Proof.** Let \( Q \) be the total output vector and \( p(Q) \) be the corresponding "full" price vector. By the definition of \( Q \),

\[
\frac{dQ}{d\gamma} = \frac{dQ^1}{d\gamma} + \frac{dQ^2}{d\gamma}.
\]  
(3.18)

Rearranging (3.10) and using \( R^2_{2c} = -(\Pi_{11}^{1c})^{-1}\Pi_{12}^{1c} \), we can have

\[
\frac{dQ^1}{d\gamma} = R^2_{1c} \frac{dQ^2}{d\gamma}.
\]  
(3.19)

Substituting (3.15) and (3.19) into (3.18) yields

\[
\frac{dQ}{d\gamma} = -[I + R^2_{2c}][I - R^2_{1c} R^2_{1c}]^{-1}\Pi_{22}^{2c} \Pi_{22}^{2c}.
\]  
(3.20)

By using the symmetry condition and \( R^2_{1c} = -(\Pi_{22}^{2c})^{-1}\Pi_{21}^{2c} \), (3.20) can be rewritten as

\textsuperscript{15} The partners and non-partner are symmetric if they have the same demand, schedule delay cost and operating cost functions, and if the partners can provide connecting services at the same level of quality as the non-partner (i.e., \( \gamma = 0 \)). However, under linear demand and schedule delay functions, the two players can be symmetric without the \( \gamma = 0 \) condition.
Using the result \((AB)^{-1} = B^{-1}A^{-1}\), we can further simplify (3.21) as follows:

\[
\left. \frac{dQ}{d\gamma} \right|_{\gamma = 0} = -\left[ \Pi_{22}^{2c} + \Pi_{21}^{2c} \right]^{-1} \Pi_{2\gamma}^{2c}. \tag{3.22}
\]

Notice that both \(\Pi_{22}^{2c}\) and \(\Pi_{21}^{2c}\) matrices are negative definite. Consequently, \(\Pi_{22}^{2c} + \Pi_{21}^{2c}\) is a negative definite matrix. Its inverse matrix, \((\Pi_{22}^{2c} + \Pi_{21}^{2c})^{-1}\) can be expressed as

\[
\frac{1}{|D|} \begin{bmatrix}
(P_{A,B_2}^{2c} + P_{A,B_1}^{2c})(P_{C,C_1}^{2c} + P_{C,C_1}^{2c}) - (P_{B,C_1}^{2c})^2 & P_{A,C_2}^{2c}P_{B,B_1}^{2c} & -P_{A,C_1}^{2c}(P_{B,B_2}^{2c} + P_{B,B_1}^{2c}) \\
0 & 0 & 0 \\
-P_{C,A_2}^{2c}(P_{B,B_2}^{2c} + P_{B,B_1}^{2c}) & -P_{C,B_1}^{2c}(P_{A,A_2}^{2c} + P_{A,A_2}^{2c}) & (P_{A,A_2}^{2c} + P_{A,A_2}^{2c})(P_{B,B_2}^{2c} + P_{B,B_1}^{2c})
\end{bmatrix}
\]

where \(D = \Pi_{22}^{2c} + \Pi_{21}^{2c}\), and subscripts A, B, and C represent AH, BH, and AB, respectively. Since every element of \((\Pi_{22}^{2c} + \Pi_{21}^{2c})^{-1}\) is strictly negative, the inverse matrix is a negative matrix. Combining it with \(\Pi_{2\gamma}^{2c}\) vector, we have \(dQ/d\gamma|_{\gamma = 0} < 0\). Thus, \(d\rho(Q)/d\gamma|_{\gamma = 0} > 0\). Consequently, consumer surplus in each market increases due to the complementary alliance.

\(Q.E.D.\)

In order to analyze changes in total welfare due to the complementary alliance, we assume a partial equilibrium framework in which consumer demand for air travel in each
market is derived from a utility function which can be approximated by the form

\[ \sum_{k=AH}^{AB} U_k(Q_k^1, Q_k^2) + z \]

where \( z \) is expenditure on a competitively supplied numeraire good, and \( \partial U_i / \partial Q_k^i = \rho_k^i \).

Recall that \( \rho_k^i \) is the "full" price (or the quality-adjusted price) of using carrier i's service in market \( k \).

Then consumer surplus in each market can be written as

\[ CS_k = U_k(Q_k^1, Q_k^2) - \rho_k^1 Q_k^1 - \rho_k^2 Q_k^2, \quad (3.23) \]

and total surplus can be written as

\[ W = \sum_{k=AH}^{AB} CS_k + \sum_{k=1}^{2} \Pi^i \quad (3.24) \]

where \( W \) may be interpreted as "World Welfare" if the markets under consideration involve different countries.

Substitution of (3.2) and (3.3) into (3.24) can yield the following expression for \( W \):

\[ W = \sum_{k=AH}^{AB} U_k(Q_k^1, Q_k^2) - \sum_{i=1}^{2} \left[ b_{AH}^i Q_{AH}^i + b_{AB}^i (Q_{AH}^i + Q_{AB}^i) + b_{BH}^i (Q_{BH}^i + Q_{AB}^i) + b_{AB}^i (Q_{AB}^i + Q_{AB}^i) \right] \]

\[ - \sum_{i=1}^{2} \left[ c_{AH}^i (Q_{AH}^i + Q_{AB}^i) + c_{BH}^i (Q_{BH}^i + Q_{AB}^i) \right] - \gamma Q_{AB}^2 \quad (3.25) \]

where again, for simplicity, superscript 2+3 is replaced by 2.

**Proposition 3-4.** For the symmetric case, total welfare rises due to the complementary
alliance.

Proof. Differentiating (3.25) with respect to $\gamma$ and using $\partial U_k/\partial Q_k^i = p_k^i = p_k + g_k^i(\cdot)$, we can show

$$\frac{dW}{d\gamma} = \sum_{i=1}^{2} \sum_{k=AH}^{BH} \left[ p_k^i - g_k^i(Q_k^i + Q_{AB}^i)(Q_{AB}^i + Q_{AB}^i - C_k^i) \right] \frac{dQ_k^i}{d\gamma}$$

$$+ \sum_{i=1}^{2} \left[ p_{AB}^i - \sum_{k=AH}^{BH} (g_k^i(Q_k^i + Q_{AB}^i)(Q_k^i + Q_{AB}^i - C_k^i)) \right] \frac{dQ_{AB}^i}{d\gamma} - \left[ Q_{AB}^2 + \gamma \frac{dQ_{AB}^2}{d\gamma} \right].$$

Notice the first and second bracketed terms of (3.26) are positive by the first-order conditions. Since $dQ_k^i/d\gamma > 0$ and $dQ_{AB}^2/d\gamma < 0$ for each market $k$, the overall effect of the complementary alliance on total welfare is not clear.

However, under the symmetry condition and $\gamma = 0$, (3.26) can be reduced to

$$\frac{dW}{d\gamma} \bigg|_{\gamma = 0} = \sum_{k=AH}^{BH} \left[ p_k^i - g_k^i(Q_k^i + Q_{AB}^i)(Q_k^i + Q_{AB}^i) - C_k^i \right] \left( \frac{dQ_k^i}{d\gamma} + \frac{dQ_{AB}^2}{d\gamma} \right)$$

$$+ \sum_{k=AH}^{BH} \left[ p_{AB}^i - \sum_{k=AH}^{BH} (g_k^i(Q_k^i + Q_{AB}^i)(Q_k^i + Q_{AB}^i) - C_k^i) \right] \left( \frac{dQ_{AB}^i}{d\gamma} + \frac{dQ_{AB}^2}{d\gamma} \right) - Q_{AB}^2.$$ 

By the first-order conditions and Proposition 3-3, $dW/d\gamma \big|_{\gamma = 0} < 0$. Q.E.D.

Proposition 3-4 provides sufficient conditions for the complementary alliance to raise welfare. However, welfare can increase even for a small positive $\gamma$. For example, in (3.26), $dW/d\gamma \big|_{\gamma = 0} < 0$ if the partners' markup in each market is greater than firm 1's markup.
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and the \( \gamma \left( dQ^2 \right) d\gamma \) term is sufficiently small.

3.4 EFFECTS OF PARALLEL ALLIANCE

3.4.1 Effects of "no shut-down" parallel alliance

Let us turn to parallel alliances. We first analyze the effect of the "no shut-down" parallel alliance where two partners continue to individually provide local services after their alliance. However, it is hard to directly sign the "overall" effect of the no shut-down parallel alliance since the effect involves switching from one situation (i.e., individual profit maximization) to another (i.e., joint profit maximization). Farrel and Shapiro (1990) use differential techniques in order to avoid similar difficulties faced in the analysis of horizontal merger effects.

To use differential techniques, we define \( \theta \) as: \( \theta = 1 \) for post-parallel alliance; \( \theta = 0 \) for pre-alliance. We then treat \( \theta \) as continuous in the range \( 0 \leq \theta \leq 1 \), and assume that carrier i's output in market k, \( Q_k^i(\theta) \), is continuous and differentiable in \( \theta \) in the entire range of interest. By these assumptions, the overall effect of switching from the pre-alliance to the "no shut-down" parallel alliance can be calculated as the integral of the infinitesimal effect in the following way:

\[ \int \left( dQ^2 \right) d\gamma \]

The concept of the infinitesimal effect originally comes from Farrel and Shapiro's horizontal merger study (1990). The infinitesimal parallel alliance may correspond to a very small amount of collaboration between the parallel alliance partners. But here we use the infinitesimal effect strictly as a mathematical construct.
\[ \Delta Q_\theta^k(\theta) = Q_\theta^k(1) - Q_\theta^k(0) = \int_0^1 \left[ dQ_\theta^k(\theta)/d\theta \right] d\theta. \]

It turns out to be easy to sign the infinitesimal effect, \( dQ_\theta^k(\theta)/d\theta \). Consequently, the overall effect, \( \Delta Q_\theta^k(\theta) \), can be determined as well if the sign of the infinitesimal effect remains unchanged in the range, which can be verified.

Based on the demand and cost specifications in Section 3.2, each firm's post-alliance profit function can be expressed as

\[
\begin{align*}
\max_{Q^1} & \Pi^1_p(Q^1, Q^2, Q^3; \theta) = \Pi^1 + \theta \cdot \Pi^2 \\
\max_{Q^2} & \Pi^2_p(Q^1, Q^2, Q^3; \theta) = \Pi^2 + \theta \cdot \Pi^1 \\
\max_{Q^3} & \Pi^3_p(Q^1, Q^3) = \Pi^3
\end{align*}
\]

where superscript \( p \) stands for parallel alliance; \( Q^1 = (Q_{AH}^1, Q_{BH}^1, Q_{AB}^1) \), \( Q^2 = Q_{AH}^2 \), \( Q^3 = Q_{BH}^3 \); and

\[
\begin{align*}
\Pi^1 &= Q_{AH}^1 \left[ d_{AH}^1(\cdot) - g_{AH}^1(\cdot) \right] + Q_{BH}^1 \left[ d_{BH}^1(\cdot) - g_{BH}^1(\cdot) \right] + Q_{AB}^1 \left[ d_{AB}^1(\cdot) - g_{AB}^1(\cdot) \right] - C_{AH}^1(\cdot) - C_{BH}^1(\cdot), \\
\Pi^2 &= Q_{AH}^2 \left[ d_{AH}^2(\cdot) - g_{AH}^2(\cdot) \right] - C_{AH}^2(\cdot), \quad \Pi^3 = Q_{BH}^2 \left[ d_{BH}^2(\cdot) - g_{BH}^2(\cdot) \right] - C_{BH}^3(\cdot).
\end{align*}
\]

We will show that unlike the complementary case, parallel alliance partners are more likely to decrease their total output in market AH after the alliance. First, we can show
**Proposition 4-1.** If the non-hub partner (i.e., firm 2) produces the same amount of output after the "no shut-down" parallel alliance, then the hub partner (i.e., firm 1) produces less outputs in all three markets, and the non-partner (i.e., firm 3) produces more output in market BH than under the pre-alliance.

**Proof.** Since the non-hub partner does not change its output in the parallel alliance, the first-order conditions for firms 1 and 3 may respectively be written as

\[ \Pi_1^{lp} = 0, \quad \Pi_3^{3p} = 0. \]

We assume that there exists a "stable" equilibrium, \((Q^1(\theta), Q^3(\theta))\), which satisfies the first-order conditions for firms 1 and 3, that is,

\[ \Pi_1^{lp}(Q^1(\theta), Q^3(\theta); \theta) = 0 \]  \hspace{1cm} (3.27)

\[ \Pi_3^{3p}(Q^1(\theta), Q^3(\theta)) = 0. \]  \hspace{1cm} (3.28)

Differentiating (3.27) and (3.28) with respect to \(\theta\) yields

\[ \Pi_1^{lp} \frac{dQ^1}{d\theta} + \Pi_3^{3p} \frac{dQ^3}{d\theta} + \Pi_1^{lp} = 0, \]  \hspace{1cm} (3.29)

\[ \Pi_3^{3p} \frac{dQ^1}{d\theta} + \Pi_3^{3p} \frac{dQ^3}{d\theta} = 0 \]  \hspace{1cm} (3.30)

where \( \Pi_1^{lp} = \left[ Q_{AH}^2 \left( \frac{\partial^2}{\partial \theta^2} Q_{AH}^1 \right), 0, 0 \right]' \), the first element of which is negative by condition (3.1).
Since both $(\Pi_{33}^{-1})$ and $\Pi_{31}$ are negative matrices, $dQ^1/d\theta$ and $dQ^3/d\theta$ have opposite signs (see equation (3.30)). Now, we show $dQ^1/d\theta < 0$. Solving (3.29) and (3.30) for $dQ^1/d\theta$, we have

$$
\frac{dQ^1}{d\theta} = -[I - R_{3}^{1p}R_{1}^{3p}]^{-1}[\Pi_{11}^{1p}]^{-1}\Pi_{10}^{1p}
$$

(3.31)

where $R_{3}^{1p} = -[\Pi_{11}^{1p}]^{-1}\Pi_{13}^{1p}$ and $R_{1}^{3p} = -[\Pi_{33}^{1p}]^{-1}\Pi_{21}^{3p}$ are derivative matrices of firm 1's (firm 3's, respectively) reaction function for firm 3's (firm 1's, respectively) output. Imposing the stability condition on the equilibrium yields that $[I - R_{3}^{1p}R_{1}^{3p}]^{-1}$ is a positive matrix. As shown in Proposition 3-1, every element of $(\Pi_{33}^{1p})^{-1}$ is negative because of the second-order conditions and the network complementarities conditions (3.4). Therefore, $dQ^1/d\theta < 0$ and $dQ^3/d\theta > 0$.

Next, we show that the signs of $dQ^1/d\theta < 0$ and $dQ^3/d\theta > 0$ remain unchanged in the entire range of interest. In (3.31), the third term, $\Pi_{10}^{1p}$, remains negative in this range since the first element of $\Pi_{10}^{1p}$ is always negative regardless of any value of $\theta$ in the range. By similar arguments, the signs of the first and second terms remain unchanged in the region. 

$Q.E.D.$
Notice that the condition $\Pi_{10}^1 < 0$ plays a crucial role in Proposition 4-1. In fact, $\Pi_{10}^1 = \Pi_1^2$, implying that firm 2's profit decreases as firm 1 produces more output in market AH. Thus, the intuition behind Proposition 4-1 is that by forming the "no shut-down" parallel alliance and maximizing joint profit, the hub partner chooses $Q^1$ taking account of the negative externalities of the hub partner's output on the non-hub partner's profit. This leads to decreases in the hub partner's output in market AH. Consequently, the hub partner decreases its BH and AB traffic due to the network complementarities. Similarly, we can show

**Proposition 4-2.** If the hub partner (i.e., firm 1) produces the same amount of output after the parallel alliance, then the non-hub partner (i.e., firm 2) decreases its output, and the non-partner (i.e., firm 3) produces the same amount of output, as compared to the pre-alliance situation.

The next question naturally arises: what if both $Q^1$ and $Q^2$ are chosen endogenously? If the two partners endogenously decide their outputs, they cannot simultaneously increase output in market AH after the parallel alliance. More specifically,

**Proposition 4-3.** $dQ^1/d\theta$ and $dQ^2/d\theta$ cannot both be positive.

**Proof.** Denoting a "stable" equilibrium by $(Q^1(\theta), Q^2(\theta), Q^3(\theta))$, and differentiating the first-order conditions with respect to $\theta$, we have
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\[ \Pi_{11}^{DQ_1} + \Pi_{12}^{DQ_2} + \Pi_{13}^{DQ_3} + \Pi_{16}^{DQ} = 0, \quad (3.32) \]

\[ \Pi_{21}^{DQ_1} + \Pi_{22}^{DQ_2} + \Pi_{20}^{DQ} = 0, \quad (3.33) \]

\[ \Pi_{31}^{DQ_1} + \Pi_{33}^{DQ_3} = 0 \quad (3.34) \]

where \( \Pi_{20}^{DQ} = \frac{1}{Q_{AH}^2} (\frac{\partial Q_{AH}^1}{\partial Q_{AH}^2}) < 0. \)

Again, from (3.34), it can be easily verified that \( \frac{dQ_1}{d\theta} \) and \( \frac{dQ_3}{d\theta} \) have opposite signs. Equations (3.32) and (3.33) show that \( \frac{dQ_1}{d\theta} \) and \( \frac{dQ_2}{d\theta} \) are interdependent.

Solving (3.32)-(3.34) for \( \frac{dQ_1}{d\theta} \) and \( \frac{dQ_2}{d\theta} \) yields

\[ \frac{dQ_1}{d\theta} = - \left[ I - R_2^{1p} R_1^{3p} \right]^{-1} \left( \Pi_{11}^{DQ_1} + \Pi_{12}^{DQ_2} \right), \quad (3.35) \]

or

\[ \frac{dQ_2}{d\theta} = - \left( \Pi_{22}^{DQ_2} \right)^{-1} \left( \Pi_{20}^{DQ_2} + \Pi_{21}^{DQ_1} \right). \quad (3.36) \]

Since \( \Pi_{12}^{DQ_1} < 0 \) and \( \Pi_{21}^{DQ_2} < 0 \) due to the strategic substitutes condition, both \( \frac{dQ_1}{d\theta} \) and \( \frac{dQ_2}{d\theta} \) cannot be positive in (3.35) and (3.36).

Q.E.D.

Notice that if \( \frac{dQ_2}{d\theta} = 0 \), then (3.35) reduces to (3.31) and Proposition 4-1 follows.
Similarly, if \( dQ_1/d\theta = 0 \), then (3.36) can be used to show Proposition 4-2.

Although both \( dQ_1/d\theta \) and \( dQ_2/d\theta \) cannot simultaneously be positive in (3.35)-(3.36), it is possible that both \( dQ_1/d\theta \) and \( dQ_2/d\theta \) are negative in (3.35)-(3.36). This can be illustrated by the following numerical example. Assume that demand is linear as follows:

\[
d_k(Q_i, Q_i) = a - (Q_i + Q_j), \quad \text{for } k = AH, BH, AB. \tag{3.37}
\]

Assume further that schedule delay cost, \( g_k(\cdot) \), is also linear and that operating cost, \( C_k(\cdot) \), is concave:

\[
g_k(Q_k) = 1 - \delta Q^i_k, \quad C_k(Q_k) = Q_k - \frac{\mu}{2}(Q_k^2), \quad \text{for } k = AH, BH, AB \tag{3.38}
\]

where \( \mu \) represents the extent of increasing returns to traffic density. Given these specifications, explicit expressions for equilibrium output can be obtained for each firm under the pre-alliance and "no shut-down" parallel alliance situations. In particular, when \( \alpha = 4, \delta = 0.03, \mu = 0.04 \), both of the partners decrease their outputs, while the non-partner increases its output. More accurately, changes in each firm's output due to the "no shut-down" alliance are \( \Delta Q^1 = (\Delta Q_{AH}^1, \Delta Q_{BH}^1, \Delta Q_{AB}^1) = (-0.2142, -0.0009, -0.0119) \); \( \Delta Q^2 = \Delta Q_{AH}^2 = -0.1404 \); and \( \Delta Q^3 = \Delta Q_{BH}^3 = 0.0009 \), respectively.

To sum up the effects of the "no shut-down" parallel alliance on each firm's outputs, the partners' total output is likely to decrease, while the non-partner's output may increase.
(by Proposition 4-1), remain unchanged (by Proposition 4-2), or decrease (by $dQ^1/dQ>0$ in Proposition 4-3). Thus, consumer surplus in market AH is likely to decrease due to this type of parallel alliance.

3.4.2 Effects of "shut-down" parallel alliance

We now analyze the effects of the second type of parallel alliance where the partners integrate local services in the AH segment in a way that the hub partner continues to provide local services, but the non-hub partner stops producing local services. However, it is intractable to compare the pre-alliance and shut-down parallel alliance by using general functions since the number of the first-order conditions for the former is not the same as that for the latter. For tractability of analysis, we impose more structure on the model. First, demands and schedule delay costs for all three markets are assumed to be symmetric. Second, in order to use a common cost function, we assume that the distances between cities A and H, and between B and H are the same. Third, we use special functions (3.37)-(3.38) for demand, schedule delay cost, and operating cost.\footnote{The linear demand and concave operating cost functions are also used in Brueckner and Spiller (1991), Brueckner, Dyer and Spiller (1992), and Nero (1996).}

Comparing the solution of the pre-alliance situation to that of the "shut-down" parallel alliance, we first examine the effects of the "shut-down" parallel alliance on each firm's output.

**Proposition 4-4.** Under the "shut-down" parallel alliance, the partners produce less output...
in market AH, but produce more outputs in markets BH and AB, and firm 3 produces less output in its local market BH than under the pre-alliance situation.

The proofs for the "shut-down" parallel alliance are provided in Appendix B. The intuitive reason for Proposition 4-4 is as follows: First of all, since the AH market is now serviced only by the hub partner, this market becomes a monopoly market. The hub-partner produces more than its pre-alliance output in this market, but less than total pre-alliance output. In other words, \( Q_{AH}^{lH} < Q_{AH}^{1p} (\equiv Q_{AH}^{(1+2)p}) < Q_{AH}^{1b} + Q_{AH}^{2b} \). Second, the hub partner increases its BH and AB traffic due to network complementarities. Third, the non-partner will decrease its BH traffic since its reaction function to the hub partner's output in market BH is downward sloping.

Next, the effects on each firm's profit are examined. As expected, under the post-alliance situation, the hub partner earns greater profit, whereas the non-partner earns less profit. However, the non-hub partner can increase or decrease its profit after the alliance. In general, the post-alliance profit of the non-hub partner (i.e., firm 2) increases when the size of markets (\( a \)) is sufficiently large for given economies of traffic density (\( \mu \)). Joining the "shut-down" parallel alliance, the non-hub partner decreases revenue from market AH since total output in this market decreases due to the alliance. But, the non-hub partner becomes more cost-effective by jointly producing the hub partner's connecting services on the AH route. If the size of markets is large enough for the partners to produce a great volume of traffic on the AH route, firm 2's gains from the cost-effectiveness dominate its
losses from the decreased revenue. To summarize the effects on each firm's profit,

**Proposition 4-5.** Under the "shut-down" parallel alliance, the hub partner earns greater profit than under the pre-alliance situation. Given economies of traffic density, the non-hub partner earns more (less, respectively) profit when the size of markets is sufficiently large (small, respectively) than under the pre-alliance situation. Firm 3 earns less profit, as compared to the pre-alliance situation.

We next examine the effects of the "shut-down" parallel alliance on total output and consumer surplus in each market. According to Proposition 4-4, passengers in market AH are worse off since total output in this market decreases while the corresponding "full" price increases. Thus, consumer surplus in market AH decreases due to the parallel alliance. However, it is not obvious whether or not consumers in market BH are better off due to the alliance.

**Proposition 4-6.** The "shut-down" parallel alliance results in increased total output and decreased "full" prices in markets BH and AB. On the other hand, the parallel alliance results in decreased total output and increased "full" price in market AH. Consequently, consumers in markets BH and AB are better off, while those in market AB are worse off.

Although Proposition 4-6 shows increases in consumer surplus in markets BH and AB due to the parallel alliance, it can be verified that decreases in consumer surplus in market AH dominate the increases in market BH and AB.

To summarize the effects of the "shut-down" parallel alliance on each firm's outputs, the partners' output decreases in market AH and increases in markets BH and AB, while the
non-partner's output decreases. Like the "no shut-down" parallel alliance, consumer surplus in market AH decreases due to the "shut-down" parallel alliance.

3.5 THE EXTENDED MODEL

The Basic Model has analyzed the effects of different types of alliances on the basis of an assumption that there is no demand shift due to the alliances. We now extend the Basic Model by taking into account potential codesharing effects on demand shifts. Under a codesharing agreement, one airline's designator code is shown on flights operated by its partner. Codesharing allows partners to offer a higher frequencies of service to consumers should the partners maintain or increase their respective frequencies. For example, before the alliance, LH and UA each provided one daily non-stop service between Washington, D.C. and Frankfurt. After the alliance, they were able to offer two daily non-stop services on the route thanks to the codesharing. It is therefore possible that the demand functions for the partners are shifted up due to the codesharing effect.

3.5.1 The complementary alliance

Assuming that the partners' "full" price demand functions in each market are shifted up due to the partners' codesharing, the partners' post-alliance (inverse) demand shifts may be written as

$$\rho_k^2 = d_k^2 (Q_k^1, Q_k^2) + \xi, \text{ for } k = AH, BH, AB$$

where $\xi$ is an exogenous demand shift due to the codesharing effect.

The post-alliance profit functions (3.6) and (3.7) can be rewritten as
In the Basic Model, \( \xi \) is set to zero. Assume that there exists a "stable" Cournot-Nash equilibrium, \((Q^1(\gamma, \xi), Q^2(\gamma, \xi))\), satisfying the first-order conditions for (3.39) and (3.40).

Differentiating the FOCs with respect to \( \xi \) and solving for \( \frac{\partial Q^1}{\partial \xi} \) and \( \frac{\partial Q^2}{\partial \xi} \), we have

\[
\frac{\partial Q^1}{\partial \xi} = -\left[ I - R_2^{1c} R_1^{2c} \right]^{-1} R_2^{1c} (\Pi_{22}^{2c})^{-1} \Pi_{22}^{2c} \tag{3.41}
\]

\[
\frac{\partial Q^2}{\partial \xi} = -\left[ I - R_1^{2c} R_2^{1c} \right]^{-1} (\Pi_{22}^{2c})^{-1} \Pi_{22}^{2c} \tag{3.42}
\]

where \( \Pi_{22}^{2c} = [1, 1, 1] \). Since \( \left[ I - R_1^{1c} R_1^{2c} \right]^{-1} > 0 \), \( R_2^{1c} < 0 \), and \( (\Pi_{22}^{2c})^{-1} < 0 \), then \( \frac{\partial Q^1}{\partial \xi} < 0 \) and \( \frac{\partial Q^2}{\partial \xi} > 0 \). This implies that the codesharing effect on the partners' demand shifts does not change the propositions derived from the Basic Model. In particular, for a given \( \gamma \), under the demand shift situation, (i) the partners (non-partner, respectively) produce more output (less output, respectively) in all three markets, and (ii) total output in each market increases more than under the Basic Model situation.

What if the non-partner's demand function is also shifted up due to the partners' codesharing effect? Oum, Park and Zhang (1996) find that a non-partner's residual demand
function is shifted upward as a result of a codesharing alliance.\footnote{There are some cases where this can happen if a major carrier drops its connecting services after a codesharing alliance with other carriers. For example, Cathay Pacific dropped its connecting services after launching codesharing services with American Airlines on the Hong Kong-Los Angeles-San Francisco route. Consequently, the demand function for the non-stop carriers between Hong Kong and San Francisco is estimated to be shifted upward (Oum, Park and Zhang, 1996).} We shall assume that the non-partner's "full" price demand function is slightly shifted up, as compared to the partners' demand shifts. We also assume that the non-partner's post-alliance (inverse) demand shift may be expressed as

\[ p_k^1 = d_k^1 (Q_k^1, Q_k^2) + \alpha \xi, \quad 0 < \alpha < 1. \]

Then, it is straightforward to show that

\[ \frac{\partial Q^1}{\partial \xi} = -\left[ R_2^{1c} R_1^{2c} \right]^{-1} \left( \Pi_1^{1c} \Pi_1^{1c} \right)^{-1} \Pi_1^{1c} + R_2^{1c} \left( \Pi_1^{2c} \right)^{-1} \Pi_1^{2c} \]

\[ \frac{\partial Q^2}{\partial \xi} = -\left[ R_1^{2c} R_2^{1c} \right]^{-1} \left( \Pi_2^{2c} \Pi_2^{2c} \right)^{-1} \Pi_2^{2c} + R_1^{2c} \left( \Pi_2^{1c} \right)^{-1} \Pi_2^{1c} \]

where \( \Pi_1^{1c} = [\alpha, \alpha, \alpha]^T \). Notice that if \( \Pi_1^{1c} \) is a zero vector, then (3.43)-(3.44) reduce to (3.41)-(3.42), respectively. Notice that the sign of the second bracketed term of the right-hand side of (3.43)-(3.44) is indeterminate. If demand functions for both partners and non-partner are simultaneously shifted up, the effects of the complementary alliance on each firm's outputs and total output are no longer clear.

However, if we assume that the partners and non-partner are symmetric and the partners can provide connecting service at the same quality as the non-partner's, then we
have

**Proposition 5-1.** In the case where demand functions for the partners and non-partner are simultaneously shifted up by the complementary alliance, both competitors can increase outputs under the symmetry and \( \gamma = 0 \) conditions.

**Proof.** Under the symmetry condition, \( R^j = R^i \) (\( \equiv R^c \)) and \( (\Pi_{11}^{le})^{-1} = (\Pi_{22}^{2c})^{-1} \). Thus, (3.43)-(3.44) can be rewritten as

\[
\frac{\partial Q^1}{\partial \xi} = -[I - (R^c)^2]^{-1}[(\Pi_{11}^{le})^{-1}\Pi_{1\xi}^{le} + R^c(\Pi_{1i}^{le})^{-1}\Pi_{2\xi}^{2c}]
\]

(3.45)

\[
\frac{\partial Q^2}{\partial \xi} = -[I - (R^c)^2]^{-1}[(\Pi_{11}^{le})^{-1}\Pi_{2\xi}^{2c} + R^c(\Pi_{1i}^{le})^{-1}\Pi_{1\xi}^{le}].
\]

(3.46)

According to the stability condition, the magnitude of the eigenvalues of matrix, \((R^c)^2\), must be less than one, and the same is true for \( R^c \). Thus, \( \partial Q^2 / \partial \xi > 0 \) since the second bracket term of (3.46) is negative. It is also possible that \( \partial Q^1 / \partial \xi > 0 \), depending on \( \alpha \). \( Q.E.D. \)

3.5.2 The parallel alliance

We will focus on the analysis of the "no shut-down" case here since the same results can be obtained for the "shut-down" case by the same analysis. Assuming that the partners' "full" price demand functions in AH market are shifted up, the partners' post-alliance (inverse) demand shifts may be written as
\[ \rho_{AH}^i d_{AH}^j (Q_{AH}^i, Q_{AH}^j) + \xi; \text{ for } i, j = 1, 2; i \neq j. \]

Denoting a "stable" equilibrium by \((Q^1(\theta, \xi), Q^2(\theta, \xi), Q^3(\theta, \xi))\), and differentiating the first-order conditions with respect to \(\xi\), we have

\[ \Pi_{11}^{lp} \frac{\partial Q^1}{\partial \xi} + \Pi_{12}^{lp} \frac{\partial Q^2}{\partial \xi} + \Pi_{13}^{lp} \frac{\partial Q^3}{\partial \xi} + \Pi_{11}^{lp} = 0, \] (3.47)

\[ \Pi_{21}^{lp} \frac{\partial Q^1}{\partial \xi} + \Pi_{22}^{lp} \frac{\partial Q^2}{\partial \xi} + \Pi_{21}^{lp} = 0, \] (3.48)

\[ \Pi_{31}^{lp} \frac{\partial Q^1}{\partial \xi} + \Pi_{33}^{lp} \frac{\partial Q^3}{\partial \xi} = 0 \] (3.49)

where \(\Pi_{11}^{lp} = [1, 0, 0]^T\) and \(\Pi_{21}^{lp} = 1\).

From (3.49), it can be easily verified that \(\frac{\partial Q^1}{\partial \xi}\) and \(\frac{\partial Q^3}{\partial \xi}\) have opposite signs.

Solving (3.47)-(3.48) for \(\frac{\partial Q^1}{\partial \xi}\) and \(\frac{\partial Q^2}{\partial \xi}\) yields

\[ \frac{\partial Q^1}{\partial \xi} = -[I - R_1^{lp} R_1^{3p}]^{-1} \left( \Pi_{11}^{lp} + \Pi_{12}^{lp} \frac{\partial Q^2}{\partial \xi} \right), \] (3.50)

or

\[ \frac{\partial Q^2}{\partial \xi} = -\left( \Pi_{22}^{lp} \right)^{-1} \left( \Pi_{21}^{lp} \frac{\partial Q^1}{\partial \xi} \right). \] (3.51)

Notice that the sign of the last term of (3.50)-(3.51) can be either positive or negative,
depending on the difference between the positive direct effects of the demand shift on each partner's marginal profit (i.e., $\Pi^{1p}_{1x}$ and $\Pi^{2p}_{2x}$) and the negative indirect effects due to strategic substitutes condition (i.e., $\Pi^{1p}_{1x}$ ($\partial Q^2/\partial x$) and $\Pi^{2p}_{2x}$ ($\partial Q^1/\partial x$)). If the direct effects simultaneously dominate the indirect effects in (3.50)-(3.51) (i.e., $|\Pi^{1p}_{1x}| > |\Pi^{2p}_{2x}$ ($\partial Q^2/\partial x$) | and $|\Pi^{2p}_{2x}| > |\Pi^{2p}_{2x}$ ($\partial Q^1/\partial x$) |), then $\partial Q^1/\partial x > 0$ and $\partial Q^2/\partial x > 0$. Therefore,

**Proposition 5-2.** If the parallel alliance shifts both partners' demand functions upward and the direct effects of demand shifts dominate the indirect effects, it is possible for both partners to simultaneously increase output in market AH. It is therefore possible that total output in market AH increases and thus consumer surplus increases.

### 3.6 Hypothesis Test

This section carries out an empirical test of some propositions regarding the effects of the alliances on each firm's outputs and total output. Previous sections have shown that complementary and parallel alliances have different effects on each firm's outputs and total output. After the complementary alliance, the partners increase local traffic (see Propositions 3-1 and 5-1). The non-partner can increase (see Proposition 3-1) or decrease (see Proposition 5-1) local traffic, depending on the degree of demand shift. Total output increases in the local markets (see Proposition 3-3).

On the other hand, from the analysis of the parallel alliances, the partners are likely
to decrease local traffic on the AH segment in both the "no shut-down" and "shut-down" cases (see Propositions 4-1, 4-2, 4-4 and 5-1). Changes in the non-partners' outputs are uncertain in the "no shut-down" case, but the non-partner decreases local traffic on the BH segment in the "shut-down" case (see Proposition 4-4). Consequently, total output on the AH segment is likely to decrease in market AH (see Propositions 4-3 and 4-6).

In order to test those predictions, we select seventeen trans-Atlantic routes\(^1\) where either complementary or parallel alliances occurred between US and European carriers. Since major alliances in the North Atlantic markets were formed in the early 1990s, annual data for two-way traffic of the seventeen routes (e.g., Atlanta to Amsterdam, and Amsterdam to Atlanta) are collected for the 1990-94 period. Observations are collected for alliance partners and their strongest competitor\(^2\) for each of the seventeen routes. The total numbers of observations available for the alliance partners and the largest non-aligned carriers are 151 and 97, respectively.

Data associated with strategic alliances are taken from the *Official Airline Guides: Worldwide Edition*. To classify the data into pre-, post-complementary, and post-parallel alliance situations, we use a variety of data sources including *Airline Business* (1994), *Gellman Research Associates* (1994), and *U.S. General Accounting Office* (1995). Thirty-six observations are classified into the complementary alliance situation, while sixteen are

\(^1\) The selection of those seventeen alliance routes is described in Section 4.3.2 of Chapter 4.

\(^2\) In order to control a firm size effect, we restrict our attention to the strongest non-aligned firm, the largest firm other than alliance partners on each of the alliance routes. Not every non-aligned firm on the route may react to the alliance.
categorized into the parallel alliance situation. Four cases are classified as a mixture of the two types (Lufthansa/United on Chicago-Frankfurt and Washington, D.C.-Frankfurt routes).

Aligned-partners' traffic, non-partners' traffic, and total traffic data on the seventeen routes are gathered from the International Civil Aviation Organization (ICAO) publication, *Traffic By Flight Stage*. The mean value for the aligned-partners' passenger volume during the period is 108,200 people, while the mean value for the total traffic is 247,770 people. The number of carriers on each route is also obtained from the ICAO publication.

Aligned-partners' traffic, non-partners' traffic, and total traffic, respectively, are treated as dependent variables in each set of regressions. As explanatory variables, presence of complementary alliance (CA), presence of parallel alliance (PA), the number of airlines on each route (NUM), year-specific characteristics (YR), and route-specific characteristics are considered. The Atlanta-Amsterdam route and year 1990 are used as a base route and year in the regression, respectively. For robustness of analysis, we test the hypotheses by using four different specifications for each set of regressions.

Table 3.1 shows the test results. The test results generally confirm the theoretical predictions. First, as shown in the first column of Table 3.1, the test result on partners' outputs is partly consistent with the corresponding propositions. As expected, all coefficients of CA are estimated as positive, regardless of the specification. However, the coefficients of CA are estimated as positive and significant only under the specifications (1) and (2). For parallel alliance partners' outputs, all coefficients are estimated as negative, implying that demand shift effects on the partners' outputs are insignificant or negative. However, the
### Table 3.1: Effects of Alliances on Partners’ Traffic, Non-partners’ Traffic, and Total Traffic

<table>
<thead>
<tr>
<th>Variables</th>
<th>(n=151)</th>
<th>(n=97)</th>
<th>(p=0.1)</th>
<th>(p=0.05)</th>
<th>(p=0.01)</th>
</tr>
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<td>1.189</td>
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<td>-0.845</td>
<td>-0.454</td>
<td>-0.487</td>
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<td>-5.379</td>
<td>-5.797</td>
<td>-6.216</td>
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<td>YR03</td>
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<td>2.176</td>
<td>2.176</td>
</tr>
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<td>2.914</td>
<td>2.914</td>
<td>2.914</td>
</tr>
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<td>-3.266</td>
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<td>BOS-AMS</td>
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### Notes
- Number in parentheses is statistic
- "a" = p-value < 0.1
- "b" = p-value < 0.05
- "c" = p-value < 0.01
### TABLE 3.1 (Continued)

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<th>Variables</th>
<th>Partners' Traffic</th>
<th>Non-partners' Traffic</th>
<th>Total Traffic</th>
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<td>(3)</td>
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<td></td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td></td>
<td>(9)</td>
<td>(10)</td>
<td>(11)</td>
</tr>
<tr>
<td></td>
<td>(13)</td>
<td>(14)</td>
<td>(15)</td>
</tr>
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<td>31,107 c</td>
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<td></td>
<td>(4.19)</td>
<td>(5.22)</td>
<td>(5.04)</td>
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<td>-4,780</td>
<td>1,540</td>
<td>-4,034</td>
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<td>(-0.81)</td>
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<td>(0.77)</td>
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<td></td>
<td>78,597 c</td>
<td>86,776 c</td>
<td>80,400 c</td>
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<td>(4.74)</td>
<td>(4.98)</td>
<td>(5.15)</td>
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<td></td>
<td>(1.85)</td>
<td>(3.42)</td>
<td>(1.34)</td>
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<td>399,590 c</td>
<td>375,050 c</td>
</tr>
<tr>
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<td>(22.95)</td>
<td>(17.08)</td>
<td>(24.41)</td>
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<td>160,630 c</td>
<td>137,530 c</td>
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<td>(1.62)</td>
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<td>189,770 c</td>
<td>171,010 c</td>
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<td>(10.46)</td>
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<td>(11.13)</td>
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<td>(5.21)</td>
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<td>(5.81)</td>
<td>(5.21)</td>
<td>(6.14)</td>
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<td>421,540 c</td>
<td>392,920 c</td>
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<td>(39.49)</td>
<td>(64.62)</td>
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<td>(12.49)</td>
<td>(17.47)</td>
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<td>57,648 c</td>
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<td>(3.56)</td>
<td>(3.52)</td>
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<td>(5.25)</td>
<td>(6.29)</td>
<td>(6.07)</td>
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<td>-22,729 c</td>
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<td>(-1.97)</td>
<td>(-2.08)</td>
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</tr>
<tr>
<td></td>
<td>-50,064 b</td>
<td>-50,454 b</td>
<td>-55,216 b</td>
</tr>
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<td>(-2.30)</td>
<td>(-2.33)</td>
<td>(-2.66)</td>
</tr>
<tr>
<td>AS-AMS</td>
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<td>16,742 c</td>
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<td>(3.72)</td>
<td>(3.11)</td>
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<td>-15,792 b</td>
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<td>(-1.67)</td>
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<td>(-2.56)</td>
</tr>
<tr>
<td></td>
<td>81,836 c</td>
<td>91,458 c</td>
<td>83,639 c</td>
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<td></td>
<td>(5.69)</td>
<td>(5.80)</td>
<td>(6.15)</td>
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<tr>
<td>WAS-FRA</td>
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<td>(9.65)</td>
<td>(9.87)</td>
<td>(8.69)</td>
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<td>60,763 c</td>
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<td>51,806 c</td>
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<td>(12.83)</td>
<td>(11.38)</td>
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<td>103,730 c</td>
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</tr>
<tr>
<td></td>
<td>(8.89)</td>
<td>(7.78)</td>
<td>(7.87)</td>
</tr>
</tbody>
</table>

| R-squared | 0.979              | 0.981                  | 0.984         | 0.985   |

**Notes:** Number in parentheses is t-statistic. <br>a: p-value<0.1, b: p-value<0.05, c: p-value<0.01
coefficients of PA are estimated as negative and significant only under the specifications (3) and (4). Nevertheless, we find some evidence that partners' traffic increases following the complementary alliance, while partners' traffic decreases following the parallel alliance.

Second, the last column of Table 3.1 shows that test results on total output are highly consistent with the corresponding predictions. The coefficients of CA and PA are estimated as proper and significant, regardless of the specification. Following the complementary alliance, total traffic increases by an average of 11-17 per cent of the average total traffic. In contrast, total traffic decreases by an average of 11-15 per cent of the average total traffic, following the parallel alliance. Notice that total passenger volumes of years 1993 and 1994 are not significantly different from that of year 1990.

Third, the second column of Table 3.1 presents insignificant effects on non-partners' outputs following alliances. The coefficients of CA and PA are estimated as insignificant in all of the non-partners' traffic regressions. According to the Basic and Extended Models, the signs of the coefficients can be positive or negative. For example, following the complementary alliance, non-partner's output decreases if there is no demand shift effect, while non-partner's output increases if there is a demand shift effect. The insignificant effects on non-partners' outputs may be related to the offsetting effects of the demand shift across the routes chosen.

3.7 SUMMARY

This chapter analyzes the effects on market outcomes and welfare of different types
of alliances: complementary alliance, "no shut-down" parallel alliance, and "shut-down" parallel alliance. To recapitulate major findings of this chapter:

First, the complementary alliance in a specific market has indirect positive effects on the partners' outputs in the other markets. Coordination in connecting markets allows the partners to increase service quality and decrease average operating costs in local markets. This is because multiple products are serviced through the same network and thus the alliance in a specific market has indirect impacts on each firm's outputs in the other markets within the same network.

Second, the complementary and parallel alliances have different effects on total output and consumer surplus. Given a symmetry condition, the complementary alliance increases total output, and decreases "full" price. Thus, consumer surplus increases as a result of the complementary alliance. On the other hand, both the "no shut-down" and "shut-down" parallel alliances are likely to decrease total output on the alliance route. Consequently, consumer surplus is likely to decrease due to the parallel alliance.

Third, the Basic Model finds sufficient conditions under which the complementary alliance improves total welfare. Given the symmetry of the partners and non-partner, total welfare can rise if the partners can coordinate to the extent that they are able to provide the same level of connecting services as firm 1.

Fourth, the Extended Model finds that demand shifts due to strategic alliances play a crucial role in the changes in firms' outputs under certain conditions. For the complementary alliance case, it is possible for both partners and non-partner to
simultaneously increase their outputs in the cases where both the partners' and non-partner's demand functions are shifted up due to the complementary alliance. The Extended Model identifies sufficient conditions under which parallel alliance partners simultaneously increase their outputs on the alliance route, resulting in increased total output in the market.

Finally, empirical test results generally confirm the theoretical predictions concerning alliance partners' outputs and total output. The test results indicate that the partners' traffic increases due to the complementary alliance, while the partners' traffic decreases due to the parallel alliance. The results also show that total traffic increases by an average of 11-17 per cent of the average total traffic due to the complementary alliance, while total traffic decreases by an average of 11-15 per cent of the average due to the parallel alliance.
CHAPTER 4. EMPIRICAL ANALYSIS:

CASES IN THE NORTH ATLANTIC MARKET

4.1 INTRODUCTION

The demand for international air travel has grown rapidly over the recent past. For example, total passenger traffic between the US and the rest of the world increased to 92.6 million passengers in 1993 from 39.5 million in 1980. The International Air Transport Association (IATA) estimates that this number will increase to 226 million by 2010.

Despite this increasing demand, the international aviation market still remains heavily regulated. Under a framework established by most allies and neutral countries gathered at the 1944 Chicago Convention, international air travel is largely governed by bilateral agreements. Two countries negotiate air services between them and award their airlines the right to offer those services.\(^1\) Airlines are greatly restricted by these agreements. For example, the current agreement between the US and UK specifies that only two US airlines can serve London Heathrow Airport, a key gateway for traffic between the US and both Europe and the Middle East.\(^2\) It is a great disadvantage for other US carriers competing

1 In general, bilateral agreements define the following: which routes can be served between the countries involved; whether or not air fares need government approval; how many flights can be offered; how many airlines from each country can fly the routes.

2 The prospect of the British Airways/American Airlines alliance has forced the UK and US back to bilateral talks where the UK will most likely sign an open skies agreement. Open skies and the US' demand for fifth-freedom rights beyond London will be prerequisites for the alliance to be granted antitrust immunity.
with these two US carriers in trans-Atlantic markets.

Although bilateral restrictions limit airlines' ability to expand international services, airlines have sought to build global networks to attract more passengers from all over the world. However, it is almost impossible for a single airline to create a truly global network under the current bilateral agreements and foreign ownership restrictions. Thus, airlines have increasingly formed strategic alliances with foreign carriers as a means of forming global networks.

Strategic alliances have both pro- and anti-competitive impacts on markets. Alliances provide opportunities for partners to reduce costs by linking their networks, and/or integrating activities in various fields. Consequently, the partners may become more cost-effective and increase their competitiveness against non-participating carriers.

Alliances enable partners to provide passengers with better quality of services. The partners can coordinate flight schedules to minimize layover time between connections. They can re-locate departure gates for connecting flights near arrival gates to decrease connecting distances.

Although many people agree with benefits from alliances, there are some concerns about the potential anticompetitive effects of alliances. Consider an alliance between two partners who were significant competitors on a specific route before the alliance.³ If the


³ Most international airline routes have a few competitors. Thus, an alliance between any two significant competitors on an international route may adversely affect degree of competition on the route.
partners integrate non-stop services on the route, they may increase their combined market power. The partners may increase air fares if they behave collusively and exploit their strengthened market power. In some cases, demand may decrease due to an alliance if the partners decrease their combined number of flights after the alliance.

For clear comparison of alliance effects, Chapter 3 models three extreme types of strategic alliances. However, most strategic alliances in reality fall somewhere between the three types. It is desirable to conduct an empirical analysis on the effects of strategic alliances on market outcomes and welfare. In addition, it appears to be an empirical question whether or not there are demand shifts due to alliances. As shown in Chapter 3, whether or not there are demand shifts due to alliances plays an important role in assessing the effects of alliances, particularly in the parallel alliance case.

The purpose of Chapter 4 is to empirically investigate the effects of four alliances on air fares, passenger volume, service quality, and alliance partners' stock values and traffic by using panel data on North Atlantic routes for the 1990-94 period or using financial market data. The North Atlantic markets are major markets for both US and European carriers. In 1994, there were 33.7 million passengers travelling on the North Atlantic routes, accounting for 12.6 per cent of total international scheduled revenue passengers that year. The North Atlantic markets are the largest intercontinental routes (IATA, 1994). The North Atlantic markets are also very important for airline alliance studies since four major alliances

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4 In this chapter, North Atlantic markets refer to all city-pair routes between North America and Europe. In 1994, trans-Pacific traffic accounted for 6.4 per cent of the total international scheduled revenue passengers, while routes between Asia and Europe carried 5.2 per cent of the total (IATA, 1994).
Chapter 4. Empirical Analysis: Cases in North Atlantic Markets

involving US carriers have been formed in these markets: BA/USAir, DL/SN/SR, LH/UA, and KLM/NW.

Specifically, the following issues are addressed in this chapter: How does each of the four alliances influence passenger volume and air fares on alliance routes? What if the alliances had not occurred in these markets? Are consumers generally better off due to the alliances? Does each of the alliances improve service quality? Are there any abnormal returns to a partner's stock value following the announcement of a new alliance? Are there any changes in a partner's stock price trend before and after the formation of the alliance? Do alliance partners increase traffic on the routes where the partners formed an alliance? If so, has each of the partners experienced greater traffic increases on these routes than those on the other routes where each has no alliance agreement?

Pricing behaviour in the airline industry has been the subject of considerable empirical study. Significant effort has been expended in the estimation of airline pricing behaviour (e.g., Abragan and Keeler 1981; Call and Keeler 1985; Bailey, Graham and Kaplan 1985; Morrison and Winston 1987; Borenstein 1989, 1990; Brander and Zhang 1990, 1993; Abbott and Thompson 1991; Dresner and Tretheway 1992; Evans and Kessides 1993; Oum, Zhang and Zhang 1993; and Maillebiau and Hansen 1995). This chapter distinctively deals with the simultaneous estimation of demand and first-order conditions for profit.

5 In June 1996, BA and AMR Corp's American Airlines (AA) announced their plans to form a strategic alliance, the largest intercontinental alliance in the airline industry. The two airlines will form a commercial alliance without equity investment to funnel passengers to each other. In 1994, BA and AA ranked number one (11.5 per cent) and three (8.1 per cent), respectively, in North Atlantic markets in terms of scheduled revenue passenger-kilometres market share (IATA, 1994).
maximization, with a markup term properly handled.

Recently, the effects of strategic airline alliances have been empirically investigated by some researchers. Gellman Research Associates (GRA, 1994) measures the impact of codesharing agreements of BA/USAir and KLM/NW on market share and welfare using data for the first quarter of 1994. They conduct a counterfactual scenario analysis based on a model estimated using the post-alliance period only. However, a proper identification of the effect of an alliance requires a comparison of with- and without-alliance situations, after taking into account structural changes caused by the alliance. This requires one to include data for both pre- and post-alliance periods in estimating a model. Since structural changes could occur due to the two strategic alliances, the effects of the alliances may be mis-estimated by the GRA's approach. USGAO (1995) concludes, mainly based on interviews with representatives from governments and airlines, that alliances between US and foreign airlines have generated large gains for the participating carriers in terms of passengers and revenues. Oum, Park and Zhang (1996) examine the effect of codesharing agreements on firm conduct and air fares by focusing on trans-Pacific markets. They estimate the impacts of a codesharing agreement between non-leaders on the market leader's price and passenger volume. What distinguishes this study is that we investigate the effects of alliances on both alliance partners and non-partners.

Section 4.2 provides more detailed information on the four alliances in the North Atlantic market. Section 4.3 derives a structural model for empirical analysis, describes the data used, and addresses the major econometric issues faced. Section 4.4 presents the results
on the effects of the alliances on air fares and passenger volume on North Atlantic alliance routes. Section 4.5 reports the effects of the alliances on service quality. Section 4.6 examines changes in the partners' stock values. Section 4.7 investigates the effects of the alliances on the partners' traffic. Section 4.8 summarizes main findings of this chapter.

4.2 FOUR MAJOR ALLIANCES IN NORTH ATLANTIC MARKETS

The four alliances examined here together have more than a 60 per cent share of the entire North Atlantic market in terms of scheduled revenue passenger-kilometres: DL plus SN, SR, and Austrian accounts for 16.5 per cent, UA/LH 15.6 per cent, BA/USAir 15.3 per cent, and KLM/NW 13 per cent (Air Transport World, May 1996).

BA formed an alliance with USAir on January 21, 1993. BA invested $300 million in USAir, which was in poor financial condition, in exchange for a 21.8 per cent control of USAir. BA also obtained 3 seats on USAir's 16-member Board of Directors. Thanks to the investment in USAir, BA has successfully linked to USAir's domestic network. BA can connect US interior cities to London by having USAir feed its domestic traffic onto BA's flights between US gateways and London. For example, after the BA/USAir alliance; BA can codeshare flights from Phoenix to London by combining codeshared USAir flights from Phoenix to Philadelphia with its own flights from Philadelphia to London. BA has further gains from this alliance because USAir is the leading carrier in major cities in the North Eastern US, where 67 per cent of all Europe-bound traffic from the US originates from. Since this alliance involves only one-sided codesharing by BA on USAir's flights within the
US and all of the alliance routes are long-haul flights across the Atlantic ocean, BA under its prorate agreement with USAir, keeps most revenues from this alliance (USGAO, 1995).

Although there is no equity involvement between DL and SN, this study regards DL/SN/SR as one alliance since DL and SR made an equity swap of about 5 per cent and SR invested in SN. This alliance ends up reducing the combined number of flights in that one partner stopped operating non-stop flights on a particular route and bought a block of seats in its partner's flights on the same route. For example, DL and SR have been codesharing on non-stop flights from Cincinnati, New York, and Atlanta to Zurich, and non-stop flights from New York to Geneva. DL continues to operate the non-stop flights between Cincinnati and Zurich with SR reserving blocks of seats, while SR continues to serve the non-stop flights on the Atlanta-Zurich, New York-Zurich and New York-Geneva routes with DL reserving blocks of seats. Another example is where DL purchases a block of seats on SN's non-stop flights between New York and Brussels where DL provided non-stop services before the alliance. This alliance is thus regarded as a "shut-down" parallel alliance since the partners were competitors before the alliance and only one partner continued to operate non-stop services after the alliance.

The LH/UA partnership, formed on June 1, 1994, is a broad commercial alliance without equity investment. In general, this alliance can be regarded as a "complementary" alliance since the partners have linked their networks. As of December 1994, LH

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6 Since DL and Austrian (OS) started a codesharing and block space arrangement on Vienna-New York in late 1994, OS is not included in the DL/SN/SR alliance for this study.
codeshared on UA flights serving 25 US cities beyond UA hubs, while UA codeshared on LH flights serving 30 European and Middle Eastern cities beyond LH hub. They also codeshared on their flights between UA and LH hubs. However, on a few non-stop routes, this alliance also has some degree of a "parallel" alliance (e.g., Washington, D.C.-Frankfurt, and Chicago-Frankfurt). But, unlike the DL/SN/SR alliance, this alliance is not a "shutdown" parallel alliance since both partners continue to serve the same number of flights on the non-stop routes. For example, each of the partners provided 31 flights between Washington, D.C. and Frankfurt in July of 1993 (pre-alliance) and of 1994 (post-alliance).

KLM invested in 25 per cent of NW's voting shares and 49 per cent of its equity as of March 1993. This alliance was the first alliance granted antitrust immunity by the US Department of Transportation in November 1992, shortly after the Netherlands and the US signed an open skies agreement in September 1992. Although each carrier's management remains separable due to foreign ownership restrictions, the carriers can closely coordinate. They are able to achieve a higher level of integration without fear of legal challenges from their competitors. They can discuss market strategies and pricing, develop formulas to set fares in all markets and quickly adjust fares according to market conditions. This alliance is a "complementary" type of partnership because the partners have linked their networks

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7 In May and June 1996, LH/UA and DL/SN/SR/OS received antitrust immunity, respectively, from the US Department of Transportation. As compared to KLM/NW's immunity, these immunities have certain routes between the partner's hubs that are still subject to antitrust laws such that the partners cannot deal with certain matters relating to certain classes of air fares and capacity on these routes: for the LH/UA alliance, the Chicago-Frankfurt and Washington, D.C.-Frankfurt routes; and for the DL/SN/SR/OS alliance, the Atlanta-Brussels, Atlanta-Zurich and Cincinnati-Zurich routes.
and have provided codeshare flights between a total of 88 North American cities beyond NW's hubs and 30 European, the Middle Eastern and African cities beyond KLM's hub as of December 31, 1994 (USGAO, 1995). A comparison between changes in the number of flights before and after the alliance indicates that the number of flights either remained the same or increased, depending on the route. After the alliance, for example, the same number of flights was offered on the New York-Amsterdam route, while the number of flights increased on the Minneapolis/St.Paul-Amsterdam and Washington, D.C.-Amsterdam routes.

**TABLE 4.1 Four Major Alliances in North-Atlantic markets**

<table>
<thead>
<tr>
<th>Alliance Partners</th>
<th>Approved Year</th>
<th>Effective Point</th>
<th>Equity Invest</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA/USAir</td>
<td>'93</td>
<td>Jan.'93</td>
<td>22%</td>
<td>Financial injection to USAir</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BA links USAir's domestic network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>One-sided codesharing</td>
</tr>
<tr>
<td>DL/SN/SR</td>
<td>'93</td>
<td>Jan.'93</td>
<td>5%</td>
<td>Competitors prior to their alliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;Shut-down&quot; Parallel alliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Combined flight frequency decreased</td>
</tr>
<tr>
<td>KLM/NW</td>
<td>'92</td>
<td>Nov.'92</td>
<td>49%</td>
<td>Antitrust Immunity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Complementary alliance</td>
</tr>
<tr>
<td>LH/UA</td>
<td>'94</td>
<td>Jun.'94</td>
<td>0%</td>
<td>Broad commercial alliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Complementary + &quot;No shut-down&quot; Parallel alliance</td>
</tr>
</tbody>
</table>

Table 4.1 provides a summary of the four strategic alliances in the North Atlantic markets. As shown in Table 4.1, each of the four alliances has different characteristics from the others. Since it is difficult to categorize the four alliances into alliance types modeled in Chapter 3, each alliance is treated as a unique case in the empirical analysis.

4.3 STRUCTURAL ESTIMATION

4.3.1 Structural model

Consider an international city-pair market where airlines produce a homogenous service. Firm i produces output $Q_i$ and total output, denoted by $Q$, is the sum of $Q_i$ for i.

Consider first the effects of alliances on demand. Alliances can cause passengers to perceive that the partners have increased their respective frequencies, owing to the codesharing between the partners. The post-alliance demand function is likely to be shifted upward as a result. However, if alliance partners decrease their combined "actual" frequency, the codesharing effect may not be strong enough to shift up the demand function. The post-alliance demand function will more likely shift down as a consequence of decreases in combined frequency. Thus, assuming that the presence of an alliance in the market may cause an exogenous demand shift, we express the market demand function as

$$Q = Q(P, A, X)$$  \hspace{1cm} (4.1)

where $P$ is market price, $A$ is a vector of alliance variables in the market, and $X$ is a vector of other exogenous variables which shifts the demand function.

Denoting airline i's costs by $C_i(Q_i)$, we can write its profit function as:
Where $P(Q, \cdot)$ is the inverse demand function. If we regard $Q_i$ as the choice variable, then the Cournot-Nash equilibrium is represented by the first-order conditions of maximizing (4.2):

$$P(Q, \cdot) + Q_i P'(Q, \cdot) = MC_i(Q_i)$$

(4.3)

where $MC_i(Q)$ is firm $i$'s marginal cost. A simple manipulation of (4.3) yields

$$P = MC_i(Q) \cdot [1 + (1/\eta) MS_i(Q)]^{-1}$$

(4.4)

where $\eta = (\partial Q/\partial P)(P/Q)$ is the price elasticity of market demand and $MS_i(Q) = Q_i/Q$ is firm $i$'s market share. Equation (4.4) shows that firm $i$'s price is determined by its marginal cost (i.e., the first term) and markup ratio (i.e., the second term). The firm's markup is positively correlated with its market share. In order to have a higher markup, the firm needs to decrease marginal cost. Some alliances may increase the partners' outputs which in turn increase their market shares, resulting in higher markups and lower marginal costs for the partners. Some alliances may directly affect the partners' marginal costs. Linking their networks and integrating various activities may enable the partners to decrease costs and thus air fares. Thus, the price equation may be affected by alliances.

Since (4.1) and (4.4) can be affected by alliances and both air fare ($P$) and passenger volume ($Q$) mutually influence each other in these equations, we shall estimate the two equations as a system of equations in order to examine the effects of alliances on market
Chapter 4. Empirical Analysis: Cases in North Atlantic Markets

outcomes and consumer surplus. This approach is within the general framework discussed in a survey paper by Bresnahan (1989).

4.3.2 Data and Variables

In order to identify North Atlantic alliance routes, we select 19 North American gateway and 12 European gateway cities. Among the routes from the combination of these gateway cities, the alliances between North American and European carriers were formed on twenty-one routes during the 1990-94 period. Two routes (Atlanta-Zurich and Cincinnati-Zurich) are excluded since substantial data described below are unavailable for these two routes. Two additional routes (Toronto-Paris and Montreal-Paris) are also eliminated because these routes are related with simple route-by-route alliances and the number of observations is not enough to distinguish the effects of major strategic alliances from those of the simple route-by-route alliances.\(^8\)

Since major alliances in North Atlantic markets were formed in the early 1990s, annual data for the remaining 17 alliance routes are collected for the 1990-94 period to compare pre- and post-alliance outcomes. Observations are collected for all carriers, aligned and non-aligned, operating on those 17 routes. Those observations are removed in which a carrier's annual flight frequency is reported as less than 50 and/or a carrier's market share

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\(^8\) We eliminate these two routes from the analysis because of the following reasons. First, the type of the alliances on these routes is a simple route-by-route alliance, different from the types of the alliances on the other alliance routes (see Section 2.3.3 for the types of alliances in detail). Second, bilateral agreements between Canada and European countries are more restricted than those between the US and European countries. Third, one of the partners on these two routes did not report its passengers carried for some years under consideration.
is less than 10 per cent.\(^9\) Finally, 368 observations are used to estimate demand and price equations and to investigate the effects of the four alliances on air fares and passenger volume on the alliance routes. Table 4.2 shows descriptive statistics and Table 4.3 provides correlations between variables.

### Table 4.2 Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Published Air Fare (US$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Summer period</td>
<td>573</td>
<td>126</td>
<td>934</td>
<td>298</td>
</tr>
<tr>
<td>. Winter period</td>
<td>539</td>
<td>126</td>
<td>960</td>
<td>249</td>
</tr>
<tr>
<td>Route total Passenger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Segment volume</td>
<td>331,950</td>
<td>349,030</td>
<td>1,382,900</td>
<td>15,086</td>
</tr>
<tr>
<td>. On-flight O&amp;D</td>
<td>315,200</td>
<td>338,920</td>
<td>1,269,300</td>
<td>14,784</td>
</tr>
<tr>
<td>An airline's passenger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Segment volume</td>
<td>90,645</td>
<td>79,854</td>
<td>480,110</td>
<td>7,461</td>
</tr>
<tr>
<td>. On-flight O&amp;D</td>
<td>86,076</td>
<td>77,674</td>
<td>484,690</td>
<td>7,377</td>
</tr>
<tr>
<td>An airline's flight frequency</td>
<td>467</td>
<td>398</td>
<td>2,552</td>
<td>74</td>
</tr>
<tr>
<td>Route distance (km)</td>
<td>6,440</td>
<td>1,009</td>
<td>8,809</td>
<td>5,254</td>
</tr>
<tr>
<td>Load factor (%)</td>
<td>0.71</td>
<td>0.08</td>
<td>0.87</td>
<td>0.40</td>
</tr>
<tr>
<td>Market share (%)</td>
<td>0.31</td>
<td>0.19</td>
<td>1.00</td>
<td>0.10</td>
</tr>
<tr>
<td>No. of carriers</td>
<td>3.66</td>
<td>1.68</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^9\) By removing those data, we can control the effects of fifth freedom carriers. Fifth freedom carriers can pick passengers from a foreign country and carry them to another foreign country. There are some fifth freedom carriers on some of the seventeen trans-Atlantic routes. We can also eliminate unreliable data by removing airlines providing less-than-one-weekly services.
### TABLE 4.3 Correlations Between Variables

<table>
<thead>
<tr>
<th></th>
<th>PW</th>
<th>PS</th>
<th>Q</th>
<th>Qi</th>
<th>DST</th>
<th>LOAD</th>
<th>NO</th>
<th>MS</th>
<th>POP</th>
<th>INC</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>.78</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>-.38</td>
<td>-.47</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qi</td>
<td>-.27</td>
<td>-.35</td>
<td>.78</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DST</td>
<td>.45</td>
<td>.45</td>
<td>-.15</td>
<td>-.14</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOAD</td>
<td>.04</td>
<td>-.03</td>
<td>.05</td>
<td>.18</td>
<td>.10</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>-.23</td>
<td>-.31</td>
<td>.70</td>
<td>.49</td>
<td>-.02</td>
<td>-.05</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>.18</td>
<td>.18</td>
<td>-.25</td>
<td>.10</td>
<td>.09</td>
<td>.16</td>
<td>-.22</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POP</td>
<td>-.31</td>
<td>-.40</td>
<td>.91</td>
<td>.69</td>
<td>.13</td>
<td>.10</td>
<td>.68</td>
<td>-.25</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>INC</td>
<td>.05</td>
<td>.08</td>
<td>.15</td>
<td>.13</td>
<td>.23</td>
<td>.22</td>
<td>-.03</td>
<td>.04</td>
<td>.22</td>
<td>1.00</td>
</tr>
</tbody>
</table>

(Notes)
PW: excursion fare in winter
PS: excursion fare in summer
Q: route total passenger
Qi: an airline's passenger volume on each route
DST: route distance
LOAD: load factor for each airline on each route
NO: the number of airlines on each route
MS: market share for each airline on each route
POP: defined as origin city population times destination city population
INC: defined as origin country's national income times destination country's national income
### TABLE 4.4 Descriptive Statistics for Sample North-Atlantic Alliance Routes

<table>
<thead>
<tr>
<th>Route</th>
<th>Alliance Between</th>
<th>Alliance Beyond</th>
<th>Post-alliance period</th>
<th>PS</th>
<th>PW</th>
<th>Q₁</th>
<th>NO</th>
<th>LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATL-AMS</td>
<td>KL/NW</td>
<td>KL/NW</td>
<td>'94~</td>
<td>656</td>
<td>640</td>
<td>56,083</td>
<td>2</td>
<td>0.71</td>
</tr>
<tr>
<td>ATL-BRU</td>
<td>DL/SN</td>
<td>-</td>
<td>'93~</td>
<td>616</td>
<td>578</td>
<td>27,308</td>
<td>2</td>
<td>0.57</td>
</tr>
<tr>
<td>ATL-FRA</td>
<td>LH/UA</td>
<td>LH/UA</td>
<td>'94~</td>
<td>698</td>
<td>643</td>
<td>76,749</td>
<td>2</td>
<td>0.71</td>
</tr>
<tr>
<td>BOS-AMS</td>
<td>KL/NW</td>
<td>KL/NW</td>
<td>'93~</td>
<td>570</td>
<td>525</td>
<td>68,846</td>
<td>1</td>
<td>0.79</td>
</tr>
<tr>
<td>BOS-LON</td>
<td>-</td>
<td>BA/US</td>
<td>'93~</td>
<td>439</td>
<td>420</td>
<td>89,628</td>
<td>3.9</td>
<td>0.74</td>
</tr>
<tr>
<td>BWI-LON</td>
<td>-</td>
<td>BA/US</td>
<td>'94~</td>
<td>479</td>
<td>465</td>
<td>26,715</td>
<td>1.4</td>
<td>0.64</td>
</tr>
<tr>
<td>CHI-FRA</td>
<td>LH/UA</td>
<td>LH/UA</td>
<td>'94~</td>
<td>687</td>
<td>625</td>
<td>61,719</td>
<td>3</td>
<td>0.72</td>
</tr>
<tr>
<td>DET-AMS</td>
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<td>KL/NW</td>
<td>'93~</td>
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<td>KL/NW</td>
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<td>NYC-BRU</td>
<td>DL/SN</td>
<td>-</td>
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<td>560</td>
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<td>48,025</td>
<td>5.2</td>
<td>0.63</td>
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<tr>
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<td>-</td>
<td>BA/US</td>
<td>'94~</td>
<td>426</td>
<td>414</td>
<td>254,740</td>
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<td>DL/SR</td>
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<td>56,335</td>
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<td>56,197</td>
<td>2.1</td>
<td>0.73</td>
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<tr>
<td>WAS-AMS</td>
<td>KL/NW</td>
<td>KL/NW</td>
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<td>540</td>
<td>37,378</td>
<td>2</td>
<td>0.67</td>
</tr>
<tr>
<td>WAS-FRA</td>
<td>LH/UA</td>
<td>LH/UA</td>
<td>'94~</td>
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<td>599</td>
<td>62,432</td>
<td>3.2</td>
<td>0.73</td>
</tr>
<tr>
<td>AVERAGE</td>
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<td></td>
<td>573</td>
<td>529</td>
<td>90,675</td>
<td>3.7</td>
<td>0.71</td>
</tr>
</tbody>
</table>

(Notes)
PS: excursion fare in summer, PW: excursion fare in winter,
Q₁: an airline's passenger volume on each route,
NO: the number of airlines on each route,
LOAD: load factor for each airline on each route.
Data associated with alliances are mainly taken from the *Official Airline Guides (OAG): Worldwide Edition*. Airlines joining alliances can be identified by the symbol "•" and their flight number in the OAG. The February and July issues for the 1989-94 period are used to check whether or not a particular alliance is still ongoing. Monthly flight frequency for each alliance is collected from these issues of OAG. To clarify unclear cases and identify the types of alliances, we also use the *Airline Business* (1994), *International Civil Aviation Organization (ICAO) Journal* (1990-94), *GRA* (1994), and *USGAO* (1995).

Table 4.4 lists alliance partners and descriptive statistics for each route included in our data set. Notice that the DL/SN/SR alliance is a sort of between-cities alliance, while the BA/USAir alliance is a beyond-cities alliance. The KLM/NW and LH/UA alliances are a combination of between- and beyond-cities alliances.

We gather each airline's excursion air fares on each route from the summer (mostly July) and winter (mostly February) issues of the OAG and compute equally weighted averages between summer air fares and winter air fares. Since the OAG reports each airline's air fares in its home currency, the official exchange rates, collected from the *International Financial Statistics*, are used to convert them into US dollars. The weighted average air fare is used as an "air fare" variable (P) in the equations.

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10 If alliance partners codeshare only on trans-Atlantic routes, this alliance is called the between-cities alliance. If alliance partners codeshare beyond trans-Atlantic routes, this alliance is called the beyond-cities alliance. The between-cities alliance is a parallel alliance, while the combination of between-cities and beyond-cities alliance is a complementary alliance.

11 To find similar excursion air fare type, we chose the lowest available fare satisfying the following criteria: (i) a minimum stay of at least 2 weeks for travelling on the route, (ii) no more than 21 days' advanced purchase required, and (iii) the ticket should be good for any particular day.
Both each airline's traffic ($Q_j$) and route total traffic ($Q$) are collected from the ICAO publications. We gather segment passenger volume between cities from the ICAO's *Traffic By Flight Stage* which lists the scheduled passenger volume for each airline. This segment passenger volume includes connecting passenger volume as well as local passenger volume on the route. In order to separate the local passenger volume from the connecting passenger volume, we also collect on-flight O&D passenger volume from the ICAO's *On-Flight Origin & Destination Traffic.* Unfortunately, this publication does not show carrier-specific O&D traffic, but total on-flight O&D traffic on each international routes. We estimate carrier-specific on-flight O&D passenger volume by using the *Traffic By Flight Stage*.

The data on population (POP) and income (INC) are collected from various sources such as *UN's Demographic Yearbook, Europa World Year Book, Statistical Abstract of the US,* and *World Almanac.* The POP variable is defined as origin city population times destination city population, while the INC variable is defined as origin country's national income times destination country's national income.

Based on the aggregate input price indices obtained from Oum and Yu (1995), we predict 1994 input price indices (INP) for each airline included in our data since they computed the indices for the world's major airlines for the 1980-93 period. The data on an airline's market share on each route ($MS_j$), its load factor (LOAD), its average aircraft size

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12 These O&D traffic data do not include one-stop and more than one-stop O&D passenger data. However, considering that non-stop O&D traffic for most of international routes occupied more than 60 per cent of total O&D traffic, the ICAO's O&D traffic data capture a substantial portion of the total O&D traffic. Also, total O&D traffic data are not available for the international routes.
on each route (SIZE), and distance between cities (DST) are computed from the *Traffic By Flight Stage*.

To measure the effects on alliance partners' stock values of the announcement of a new alliance and of the operation of that alliance, we collect from Datastream financial market data including the partners' stock prices and stock price returns, and their national transport composite index. In Section 4.6, the data will be described in detail.

For the comparison of alliance partners' traffic changes between alliance and non-alliance routes, traffic data on twenty-five non-alliance routes are collected. The data associated with these routes will be fully described in Section 4.7.

### 4.3.3 Econometric Issues

In estimating the system of demand and price equations, we encounter a number of econometric issues. Of these, the most significant are functional specification, estimation method, inclusion of proper specification, appropriate treatment of error structures, and specification of fixed effects. We now address each of these issues.

As shown in Subsection 4.3.1, a common price elasticity needs to be imposed on both demand and price equations. Since a log-linear specification allows us to embed an explicit form of the price elasticity into the system of equations, we apply the log-linear specification to the demand equation. Assuming that the four major alliances have an impact
on demands in individual North Atlantic markets, \(^{13}\) we may express the demand equation as

\[
\ln Q = a_0 + a_1 \ln P + a_2 \ln \text{POP} + a_3 \ln \text{INC} + a_4 \text{BAUS} + a_5 \text{DLNR} + a_6 \text{KLNW} + a_7 \text{LHUA} \tag{4.5}
\]

where \(Q\) is aggregate annual traffic on each route, \(P\) is an equally weighted average air fare of summer and winter excursion fares on the route, and \(\text{BAUS}, \text{DLNR}, \text{KLNW}\) and \(\text{LHUA}\) are post-alliance dummy variables for each of the four alliances, respectively.

For the consistency of the functional structure, equation (4.4) is transformed in the logarithmic form:

\[
\ln P = \ln MC(Q) - \ln[1 + (1/a_i)MS_i(Q)]. \tag{4.6}
\]

Assuming that the four major alliances affect their respective marginal cost function, we express the marginal cost function as\(^{14}\)

\[
\ln MC_i = b_0 + b_1 \ln Q_i + b_2 \ln \text{NP} + b_3 \ln \text{DST} + b_4 \ln \text{SIZE} + b_5 \text{BPARI} + b_6 \text{DPARI} + b_7 \text{KPAR} + b_8 \text{LPAR} \tag{4.7}
\]

where \(MC_i\) is firm \(i\)'s marginal cost on each route, \(Q_i\) is the firm's annual traffic on each route.

\(^{13}\) By using the likelihood test, we tested whether or not slopes and intercepts of route demand and price equations are changed by each of the four alliances. The test results showed that the post-alliance slopes of the two equations are not significantly different from the pre-alliance slopes, while the two equations are significantly shifted by the alliances. Thus, we estimate the system of equations on the basis of the assumption that the slopes of the two equations are not affected by the alliances.

\(^{14}\) Initially, equation (4.7) included post-alliance dummy variables for non-aligned carriers to examine whether or not the marginal cost functions for the non-aligned carriers are affected by the alliances. All of the coefficients of the post-alliance dummies for the non-aligned carriers were estimated as insignificant. By using the likelihood test, we tested the null hypothesis that the coefficients of the post-alliance dummies for the non-aligned carriers are zero. Since the log-likelihood values of unrestricted and restricted models were estimated as -238.75 and -238.98, respectively, the likelihood test did not reject the restriction. Thus, for the simplicity of the exposition, we exclude the post-alliance dummies for the non-aligned carriers hereafter.
route, INP is its overall (not route-specific) input price index, DST is the route distance, SIZE is firm i's average aircraft size used on the route, and BPAR, DPAR, KPAR and LPAR are post-alliance dummy variables for partners for each of the alliances, respectively.

Notice that the second term of the right-hand side of equation (4.6) implies firm i's markup ratio. With this markup ratio term excluded, estimating the system of equations (4.5) and (4.6) will result in biased and inconsistent estimates. Thus, this markup ratio term should be properly handled when both demand and price equations are simultaneously estimated.\(^{15}\)

In order to appropriately handle the markup ratio term in (4.6), we need to impose the following two restrictions on the system of equations: (i) \(1 + (1/a_t) MS_i(Q)\) should be estimated as greater than or equal to unity; and (ii) coefficient \(a_t\) should be estimated as the same negative value in both equations. The problem is how to properly estimate coefficient \(a_t\) in the price equation. Since the coefficient is implanted within the markup ratio term, it is necessary to use a nonlinear estimation method. However, this method fails to obtain reliable estimates. During the iterations, the term often goes out of the proper range and thus is replaced by zero, an irrelevant number. In order to avoid this problem, we approximate \(\ln[1 + (1/a_t) MS_i(Q)]\) by \((1/a_t) MS_i(Q)\) by using Taylor's first-order expansion

\(^{15}\) Methodologically, the empirical literature has taken two approaches to estimating price equation. The first approach is to estimate a single (reduced-form) price equation. Most studies using this approach, however, do not explicitly derive the reduced-form equation from the system or model. For example, see Borenstein (1989), Evans and Kessides (1993), Youssef and Hansen (1994), and Maillebiau and Hansen (1995). The second approach is to estimate multiple equations simultaneously, but the markup ratio term is not explicitly specified in price equation. For example, see Graham, Kaplan and Sibley (1983), and Dresner and Tretheway (1992).
of function \( f(x) = \ln(1 + x) \) at \( x = 0 \).\(^{16}\)

We assume that equations (4.5)-(4.6) have an additive error structure of the following form:

\[
\begin{align*}
\ln Q_{jt} &= D(P, POP, INC, BAUS, DLNR, KLNW, LHUA; \alpha) + \varepsilon_{jt} \\
\ln P_{jt} &= P(Q_i, INP, DST, SIZE, BPAR, DPAR, KPAR, LPAR, MS_{ij}; \beta) + u_{ijt}
\end{align*}
\]

where \( \alpha \) and \( \beta \) are the parameter vector to be estimated and subscripts \( i, j \) and \( t \) represent carrier, route and year indices, respectively.

Similarly to the Friedlander et al. (1993) railway cost study, the error term in the demand equation is decomposed into three components while the error term in the price equation is decomposed into four components: a carrier-specific \( (\gamma_i) \), a route-specific \( (\delta_j \) and \( \sigma_j) \), a year-specific errors \( (\zeta_t \) and \( \xi_t) \), and a normally distributed error term \( (\omega_{jt} \) and \( e_{ijt}) \) that may be contemporaneously correlated across equations only. Therefore,

\[
\begin{align*}
\varepsilon_{jt} &= \delta_j + \zeta_t + \omega_{jt} \\
u_{ijt} &= \gamma_i + \sigma_j + \xi_t + e_{ijt}
\end{align*}
\]

The carrier-specific error term reflects unobserved fundamental differences across airlines. For example, network structure, management style, and fleet composition are

\(^{16}\) Taylor’s first-order expansion of function \( f(x) = \ln(1 + x) \) at \( x = 0 \) can be written as

\[
f(x) = f(0) + f'(0)x + R \quad \text{or} \quad \ln(1 + x) = x + R
\]

where \( R \) is the residual which approaches to zero as \( x \) approaches to zero. If \( x = \left(1/a_i\right)MS_i(Q_{ij}) \) is estimated to be close to zero, this approximation may be reasonable.
different across airlines. Some airlines tend to charge higher markups. By introducing dummy variables for each carrier, the carrier-specific effect can be controlled. The route-specific effect is designed to capture demand and cost (or price) differences that are unmeasured and constant for all airlines that serve a route, but may vary across routes. Demand and price may differ across routes, with other things held constant, due to various reasons: for example, whether a route is primarily business or tourist travel, whether the route is under a 'restricted' or 'liberal' bilateral agreement. In order to control the inter-route heterogeneity, we introduce dummy variables for routes. Similarly, we capture the year-specific effect by employing year dummy variables. American Airlines, the Atlanta-Amsterdam route and year 1990 are used as a base carrier, a base route and a base year respectively and therefore, they are omitted from the dummy variables.

Following the above stochastic specification, we can transform (4.5) and (4.6) into

\[
\ln Q = D(P, POP, INC, BAUS, DLNR, KLNW, LHUA; \alpha) + \sum R_j R_T_j + \sum Y_t Y_R_t + \omega_t \quad (4.10)
\]

\[
\ln P = P(Q, INF, DST, SIZE, BPAR, DPAR, KPAR, LPAR, MS; \beta) + \sum f_i F_i + \sum r_j R_T_j + \sum y_t Y_R_t + \varepsilon_t \quad (4.11)
\]

where \( F_i \) is a firm-specific dummy variable for carrier \( i \), \( R_T_j \) is a route-specific dummy variable for route \( j \) and \( Y_R_t \) is a year-specific dummy variable for year \( t \).

4.4 EFFECTS OF ALLIANCES ON FARES AND PASSENGER VOLUME

4.4.1 Effects on variables in demand equation

The model, consisting of equations (4.10)-(4.11), is estimated using Nonlinear
Three Stage Least Squares. The estimation result is provided in Table 4.5. Since the demand equation is specified as the log-linear form, the coefficient of ln P is the price elasticity of aggregate demand for the excursion classes on the individual alliance routes. The price elasticity is estimated as -1.074, indicating that a one per cent increase in excursion air fares results in a 1.07 per cent decrease in aggregate demand on the individual alliance routes on average. The population elasticity is estimated as 1.433.

The coefficient of BAUS is estimated as 0.126. This means that the aggregate demand function on the trans-Atlantic routes, onto which USAir fed its domestic traffic for BA during the post-period of the alliance, is shifted upward by an average of 13 per cent over the pre-alliance demand function level. Forming the alliance with USAir, BA was able to connect 38 US interior cities to London through 7 US gateway cities as of July 1994. Since USAir fed its domestic traffic onto BA's flights between the seven US gateways and London, BA could take advantage of high traffic density on the trans-Atlantic routes. This estimation result can be supported by BA's argument saying that connecting traffic between BA and USAir doubled in 1994-5 and amounted to about 375 passengers every day on average, which is equivalent to one Boeing 747 a day (BA Fact Book, 1995).

The coefficient of DLNR is estimated as -0.25, implying that the post-alliance demand on the alliance routes decreases by 25 per cent on average from the pre-alliance demand level. The reason can be explained by the following observations: First, unlike the other alliances, this alliance is not a beyond-cities alliance (see Table 4.4). Until recently, each of the partners did not feed its domestic or intra-continental traffic onto its partner's
trans-Atlantic flights between the US and Belgian (or Swiss) gateways. Second, the partners reduced the number of their combined flights in such a way that one partner stopped flying on a route and bought a block of seats in the other partner's flights on the route. For example, both DL and SN provided daily non-stop services for passengers in the New York-Brussels market in July 1992. After forming the alliance, DL stopped its non-stop services and purchased a block of seats from SN. Another example is that both DL and SR provided daily non-stop services on the New York-Zurich route in July 1992 (pre-alliance), but only SR continued to provide "actual" daily services in the market in July 1993 (post-alliance). GRA (1994) states a similar argument, saying that the hub-to-hub share of DL/SR's trans-Atlantic traffic actually declined after the alliance was first signed.

The coefficients of KLNW and LHUA are estimated as 0.354 and 0.132, respectively, implying that aggregate demands increase by 35 per cent and 13 per cent on the respective alliance routes. These two alliances are similar in the following perspectives: First, the partners formed a "complementary" network so that each partner has been able to reach further distant points through its partner's hubs. Second, after the alliance, both partners provided at least the same number of flights as that of pre-alliance. The successful network linkage and frequency maintenance would allow the partners to feed more traffic to each other, resulting in increased the partners' demand and thus increased route total demand.

17 Checking the July 1996 issue of OAG, we found that DL/SN/SR partners expanded their trans-Atlantic alliance routes to a number of destinations in Belgium, Germany, and Switzerland via Brussels, Geneva, and Zurich and that they did not expand their trans-Atlantic alliance routes to US domestic cities via DL's hubs.
### TABLE 4.5 The N3SLS Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>t-stat.</th>
<th>Variable</th>
<th>Estimate</th>
<th>t-stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand Equation</strong></td>
<td></td>
<td></td>
<td><strong>Price Equation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
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<td>Constant</td>
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</tr>
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<td>ln(Qi)</td>
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</tr>
<tr>
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<td>ln(INP)</td>
<td>0.009</td>
<td>0.86</td>
</tr>
<tr>
<td>ln(INC)</td>
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<td>-0.06</td>
<td>ln(DST)</td>
<td>-10.421</td>
<td>-2.49 c</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ln(SIZE)</td>
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<td>-1.82 a</td>
</tr>
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<td>BAUS</td>
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<td>BPAR</td>
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</tr>
<tr>
<td>DLNR</td>
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<td>DPAR</td>
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<td>-2.09 b</td>
</tr>
<tr>
<td>KLNW</td>
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<td>5.16 c</td>
<td>KPAR</td>
<td>-0.218</td>
<td>-1.94 a</td>
</tr>
<tr>
<td>LHUA</td>
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<td>1.84 a</td>
<td>LPAR</td>
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<td>YR91</td>
<td>0.121</td>
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</tr>
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<td>0.03</td>
<td>YR92</td>
<td>0.031</td>
<td>1.04</td>
</tr>
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<td>YR93</td>
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</tr>
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<td>YR94</td>
<td>-0.047</td>
<td>-0.97</td>
</tr>
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<td>ATL-BRU</td>
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<td>1.34</td>
</tr>
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<td>ATL-FRA</td>
<td>0.385</td>
<td>3.04 c</td>
</tr>
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<td>BOS-LON</td>
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<td>-2.49 c</td>
</tr>
<tr>
<td>BWI-LON</td>
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<td>-2.59 c</td>
<td>BWI-LON</td>
<td>-1.768</td>
<td>-2.89 c</td>
</tr>
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<td>CHI-FRA</td>
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<td>-0.33</td>
</tr>
<tr>
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<td>DET-AMS</td>
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</tr>
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</tr>
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<td>MSP-AMS</td>
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<td>NYC-BRU</td>
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<td>NYC-ZRH</td>
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<td>-2.10 b</td>
</tr>
<tr>
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<td>PHL-LON</td>
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<td>-3.09 c</td>
</tr>
<tr>
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<td>-2.99 c</td>
<td>WAS-AMS</td>
<td>-1.225</td>
<td>-3.01 c</td>
</tr>
<tr>
<td>WAS-FRA</td>
<td>-2.803</td>
<td>-1.52</td>
<td>WAS-FRA</td>
<td>-0.759</td>
<td>-1.94 a</td>
</tr>
</tbody>
</table>

R² 0.99 R² 0.98

(Notes) a : p-value < 0.1, b : p-value < 0.05, c : p-value < 0.01
4.4.2 Effects on variables in price equation

As shown in the price equation of Table 4.5, many of the coefficients of carrier-specific, year-specific, and route-specific dummy variables are estimated as significant, implying that unobserved variations across carriers, year, and/or routes are captured by these dummy variables.

As shown in equation (4.6), we can estimate an airline's markup ratio on a route on the basis of the estimate of the price elasticity and its market share on the route. Evaluating the market share at the mean, we estimate the average markup ratio as 1.41. This indicates that North Atlantic airlines charge an average markup of 41 per cent above their marginal cost.18

Turning to the alliance variables, the coefficient of DPAR is estimated as -0.189. This means that the partners decrease air fares by an average of 19 per cent on the alliance routes during the post-alliance period.19 Forming the "shut-down" parallel alliance, they could reduce their combined cost on the existing alliance routes and utilize their "extra" resources such as aircraft and flight attendants for serving another alliance route. For example, in July 1992, both DL and SN provided daily non-stop services on the New York-

---

18 Since indirect operating cost is not considered in the estimation, this markup estimate may be overestimated. The indirect operating cost includes passenger service, aircraft service, promotion and sales, general and administration cost, amortization of development and pre-operating expenses, and depreciation other than flight equipment. An airline's indirect operating cost occupies 40-45% of its total operating cost (e.g., Sandal, Oum, and Statton, 1978).

19 Using equations (4.6)-(4.7), we separated marginal cost and markup ratio for each observation for the DL/SN/SR alliance and compared each of the two parts between pre- and post-alliance periods. We found that marginal cost decreases by $70, while markup ratio increases by 30% during the post-alliance period. Since decreases in the marginal cost dominate increases in the markup ratio, the air fares are estimated to decrease by an average of 19% during the post-alliance period.
Brussels route, but neither of them provided non-stop services on the Atlanta-Brussels route. After the alliance, DL discontinued non-stop flights on the New York-Brussels route, but still served the route by using SN's block of seats. In addition, utilizing its "extra" resource, DL could provide new daily non-stop services on the Atlanta-Brussels route where SN could also provide new daily non-stop services by using DL's block of seats.

The coefficient of KPAR is estimated as -0.218, showing that the partners decrease air fares by an average of 22 per cent on the alliance routes. Until 1996, this alliance was the only alliance granted antitrust immunity by the US government. The immunity allows the partners to more greatly integrate their operations in various areas than those partners without the immunity could do. They may also take advantage of higher traffic density through the linkage of existing networks and codesharing operations.

The coefficients of BPAR and LPAR are estimated as insignificant. As shown in Table 4.1, the BA/USAir alliance is the one-sided alliance by BA on USAir's flights within the US. The coefficient of BPAR may be estimated as insignificant because the partners did not integrate their operations on the trans-Atlantic routes. The LPAR insignificance may be related to the fact that this alliance has been recently formed. Although the LH/UA alliance is similar to the KLM/NW alliance in the sense that the partners link their existing networks, the number of observations for the LH/UA alliance may be insufficient to examine structural changes in the price equation.

20 To check this, we compared pre- and post-alliance load factors on the alliance routes, and tested the null hypothesis that there is no difference between the two load factors. We found that on these routes the partners significantly increase load factor from 71 per cent to 76 per cent after the alliance.
4.4.3 Effects of alliances on equilibrium fares and passenger volume

This section examines the effects of the alliances on equilibrium air fares and passenger volume based on the estimates reported in Table 4.5. Since the KLM/NW alliance shifts the demand function upward and the price function downward, passenger volume increases after the alliance while air fares may increase or decrease depending on the slope of the price equation. Given that the price equation estimated is fairly flat, air fares are likely to fall. It is obvious that equilibrium passenger volume will increase due to the BA/USAir and LH/UA alliances since the alliances shift up their respective demand function. However, it is not obvious whether equilibrium passenger volume increases or decreases due to the DL/SN/SR alliance since this alliance shifts the demand and price equations downward in a simultaneous manner. Thus, in order to measure changes in equilibrium air fares and passenger volume due to the alliances, we need to compare the with-alliance equilibrium ($Q_1$ and $P_1$) to without-alliance equilibrium ($Q_0$ and $P_0$). The without-alliance equilibrium in a particular market is what would have happened if no such alliance had existed in the market.

To accomplish this, we simplify and rearrange (4.10) and (4.11) to yield equilibrium air fares and passenger volume

$$
\Delta Q = Q_1 - Q_0 = [\exp(A_1) - \exp(A_0)]\exp(a_0 + A_c)P_0^a
$$

$$
\Delta P = P_1 - P_0 = [\exp(B_1) - \exp(B_0)]\exp(b_0 + B_c)Q_0^b
$$

(4.12)

where $A_1$ and $B_1$ are the terms where variables associated with alliances in the demand and
price equations are 1 respectively; $A_0$ and $B_0$ are the terms where variables associated with alliances in the two equations are 0 respectively; 

$$A_c = a_2 \ln POP + a_3 \ln INC + \sum R_j RT_j + \sum Y_j Y R_i;$$

and 

$$B_c = b_2 \ln INP + b_3 \ln DST + b_4 \ln SIZE + \sum f_i F_i + \sum _j r_i RT_j + \sum _j Y_j Y R_i.$$

We calculate $\Delta P$ and $\Delta Q$ values for each of 100 post-alliance data points based on the previous estimation results and then treat each of these calculated values as an "observation" consisting of a common element and an error. We therefore convert (4.12) into the following stochastic specifications:

$$\Delta Q = \Delta q + u_q$$

$$\Delta P = \Delta p + u_p$$

(4.13)

where $\Delta q$ and $\Delta p$ are the expected values of passenger volume and price differences between with- and without-alliance equilibria, and $u_q$ and $u_p$ are random deviations of $\Delta Q$ and $\Delta P$ from their expected values with mean zero.

We estimate the mean and standard deviation of $\Delta q$ and $\Delta p$, and then test the null hypotheses that there are no changes between with- and without-alliance equilibria. The test results are reported in Table 4.6.

As expected, complementary alliances increase equilibrium passenger volume, while a parallel alliance decreases equilibrium passenger volume. For the BA/USAir and LH/UA alliances, the mean values for $\Delta q$ are estimated as 65,626 and 25,616, respectively. For the KLM/NW alliance, the mean values for $\Delta q$ and $\Delta p$ are estimated to increase
TABLE 4.6 Changes in Air Fares and Passengers due to the Alliances

<table>
<thead>
<tr>
<th>Alliance</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-stat.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δq</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BA/USAir (n=41)</td>
<td>65,626</td>
<td>53,020</td>
<td>7.93 c</td>
<td>175,580</td>
<td>4,326</td>
</tr>
<tr>
<td>DL/SN/SR (n=20)</td>
<td>-28,863</td>
<td>13,276</td>
<td>-9.72 c</td>
<td>-11,689</td>
<td>-48,904</td>
</tr>
<tr>
<td></td>
<td>Δp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-89.7</td>
<td>66.9</td>
<td>-5.99 c</td>
<td>0</td>
<td>-192.5</td>
</tr>
<tr>
<td>KLM/NW (n=23)</td>
<td>46,866</td>
<td>46,663</td>
<td>4.82 c</td>
<td>173,331</td>
<td>12,533</td>
</tr>
<tr>
<td></td>
<td>Δq</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-98.8</td>
<td>70.9</td>
<td>6.68 c</td>
<td>0</td>
<td>-244.0</td>
</tr>
<tr>
<td>LH/UA (n=16)</td>
<td>25,616</td>
<td>2,348</td>
<td>43.64 c</td>
<td>29,443</td>
<td>23,463</td>
</tr>
<tr>
<td>Total (n=100)</td>
<td>35,998</td>
<td>53,971</td>
<td>6.67 c</td>
<td>175,580</td>
<td>-48,904</td>
</tr>
<tr>
<td></td>
<td>Δq</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-40.7</td>
<td>64.8</td>
<td>-6.28 c</td>
<td>0</td>
<td>-244.0</td>
</tr>
<tr>
<td></td>
<td>Δp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Notes) Δp = 0 for BA/USAir and LH/UA since the coefficients of BPAR and LPAR in the price equation are estimated as insignificant.

a: p-value < 0.1,  b: p-value < 0.05,  c: p-value < 0.01

equilibrium passenger volume by 46,866 passengers and to decrease equilibrium air fares by $99 in the markets where these alliances exist. However, for the DL/SN/SR alliance, the mean values for both Δp and Δq are estimated as negative. Although this alliance lowers air fares by taking advantage of "integrated" operations, it is not enough to dominate the
demand losses resulting from reduced combined flight frequency. As a result, this alliance decreases annual passenger volume by 28,863 on average. Finally, without distinguishing alliance types, total $\Delta p$ and $\Delta q$ are also estimated to see the overall pattern of changes in equilibrium passenger volume and air fares. In general, the equilibrium annual passenger volume increases by 35,998 passengers on average, while the equilibrium air fares decrease, on average, by $41$ on the alliance routes under consideration.

4.4.4 Effects of alliances on consumer surplus

Since the KLM/NW alliance is estimated to increase passenger volume and to decrease air fares on the alliance routes, consumers in these markets are better off due to the alliance. By a similar argument, we expect that consumers are better off in the markets where the BA/USAir and LH/UA alliances occurred. However, it is not clear whether or not consumers are better off due to the DL/SN/SR alliance, as compared to the without-alliance situation. This section examines the effects of these alliances on consumer surplus.

Defining $\Delta CS$ as the difference between consumer surplus under with-alliance condition ($CS_1$) and consumer surplus under without-alliance condition ($CS_0$), we can derive $\Delta CS$ as follows:

\[
\Delta CS = CS_1 - CS_0 = \left[ \exp(A_1) - \exp(A_0) \right] \left\{ \int_{P_1}^{\bar{p}_1} x^{a_1} dx - \int_{P_0}^{\bar{p}_0} y^{a_1} dy \right\} \tag{4.14}
\]

where $\bar{p}_1$ and $\bar{p}_0$ are upper bound prices satisfying $\exp(a_0 + A_0)\exp(A_1)p^{a_1}=1$ and
exp(a_0 + A_p) exp(A_p) p^{a_1} = 1,$ respectively.

### TABLE 4.7 Changes in Consumer Surplus due to the Alliances

<table>
<thead>
<tr>
<th>Alliance</th>
<th>Mean (thousand)</th>
<th>Standard Deviation (thousand)</th>
<th>t-stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA/USAir (n=41)</td>
<td>ΔCS 229,260</td>
<td>27,407</td>
<td>8.4 c</td>
</tr>
<tr>
<td>DL/SN/SR (n=20)</td>
<td>ΔCS -120,720</td>
<td>11,443</td>
<td>-10.5 c</td>
</tr>
<tr>
<td>KLM/NW (n=23)</td>
<td>ΔCS 193,510</td>
<td>31,544</td>
<td>6.1 c</td>
</tr>
<tr>
<td>LH/UA (n=16)</td>
<td>ΔCS 122,380</td>
<td>1,392</td>
<td>87.9 c</td>
</tr>
<tr>
<td>TOTAL (n=100)</td>
<td>ΔCS 130,210</td>
<td>18,852</td>
<td>6.9 c</td>
</tr>
</tbody>
</table>

(Note) a: p-value < 0.1, b: p-value < 0.05, c: p-value < 0.01

Table 4.7 shows changes in consumer surplus due to the alliances. The t-test allows us to reject the null hypotheses that there are no changes in consumer surplus due to the alliances. All of the alliances being considered together, they increase consumer benefits by $130 million during the post-alliance period.\(^{21}\) However, not every alliance increases

---

\(^{21}\) This increase in consumer surplus amounts to a 12 per cent increase as compared to the without-alliance situation (about $1.01 billion). However, the increase in consumer surplus may be overestimated because of the specification of the demand equation. The slope of constant price elasticity demand approaches infinity in magnitude as Q (i.e., the number of passengers) approaches zero, causing huge consumer surpluses around small Q. To alleviate this problem, we truncated the consumer surplus at Q=1. Previous studies using the same demand specification have faced similar difficulties (e.g., Maillebiau and Hansen, 1995).
consumer surplus if we individually estimate changes in consumer surplus. Due to the
BA/USAir, KLM/NW, and LH/UA alliances, consumer benefits are estimated to increase
by $229 million, $193 million, and $122 million, respectively, while consumer surplus is
estimated to decrease by $120 million due to the DL/SN/SR alliance.

It is worthwhile to note that the effects on consumer benefits in Table 4.7 may be
underestimated since a "full" price variable is not used for the estimated demand and price
equations. If travellers are able to place a dollar value on service quality, then full price is
the sum of air fare and the value of service quality (e.g., De Vany, 1974; and Panzar,
1979). Close coordination between alliance partners may provide better service quality to
travellers, which would shift the estimated demand equation further upward if the "full"
price model were considered in the empirical analysis.

4.5 EFFECTS OF ALLIANCES ON SERVICE QUALITY

Alliances allow partners involved to provide better service quality to travellers.
The partners can coordinate arrival and departure flight schedules to minimize travellers'
waiting time between flights while providing sufficient time for connections. Joint baggage

22 GRA (1994) examines the effects of the BA/USAir and KLM/NW alliances on market share and welfare
using a different approach. Using post-alliance period data only, they estimate an individual's carrier choice
function and then conduct a counter-factual scenario analysis by changing attribute values for each explanatory
variable in the estimated choice function. On the basis of this estimation they calculate changes in market
share and welfare due to the alliances. In particular, they estimate that the BA/USAir and KLM/NW alliances
increase consumer surplus by $10.3 million and $27.1 million, respectively, during the first quarter of 1994.
However, since structural changes could occur due to the two alliances, the estimate may be distorted by the
GRA approach. In order to properly estimate the effects of the alliances, one requires to compare with- and
without-alliance equilibria after accounting for structural changes caused by the alliances.
handling eliminates the need to retrieve and re-check baggage at a connecting place, and thus reduces the risk associated with interline handling in which no one carrier has the sole responsibility for the baggage.

A codesharing alliance enables the partners to increase flight frequencies and thus allows travellers to decrease their schedule delay times. For example, each of LH/UA partners provided one daily non-stop service between Washington, D.C. and Frankfurt in July 1993 (pre-alliance). Each partner was able to provide two daily non-stop services on the route in July 1994 (post-alliance). Previous works have found that a passenger's schedule delay time, defined as the difference between the passenger's desired departure and actual departure time, is one of the most important aspects of service quality. Douglas and Miller (1974) decompose this schedule delay time into two parts: (i) the difference between a traveller's desired departure time and the closest schedule departure time (called "frequency delay time"), and (ii) the delay caused by excess demand for one's preferred flight (called "stochastic delay time"). In this section, we compare pre- and post-alliance schedule delay times for each of the four alliances to examine whether or not schedule delay times decrease due to the alliances.

By following the Douglas and Miller (1974) specification, schedule delay times for each partner of the four alliances on the seventeen alliance routes are computed as follows:

---

23 Literature on airline deregulation has emphasized importance of schedule delay time. For example, Morrison and Winston (1986, pp.32-33) estimate that about two-thirds of consumer welfare gains from the US deregulation are attributable to reduction in schedule delay time achieved by increase in service frequency. See, also, Winston (1993, Tables 3 and 6).
\[ T = T_1 + T_2 = 92 F^{-0.456} + 0.455 Y^{-0.645} X^{-1.79} F^{-1} \] (4.15)

where \( T \) is the expected schedule delay per passenger (in minutes), \( F \) is average daily frequency, \( Y \) is average passengers per flight, and \( X \) is average excess seats per flight. The first term of the right-hand side of (4.15) is frequency delay time, while the second term is stochastic delay time.

To compare pre- and post-alliance schedule delay times for each of the alliances, we conduct the following regression for each alliance:

\[ T_t = \alpha_0 + \alpha_1 POSTAL_t + \sum \alpha_i YR_i + \epsilon_t \] (4.16)

where \( POSTAL_t \) is one if an airline is in the post-alliance period at year \( t \), zero otherwise; \( YR_i \) is a year dummy variable; and \( \epsilon_t \) is an error term. The coefficient of \( POSTAL \) implies change in schedule delay time due to the alliance. Since schedule delay time may decrease with year, year dummy variables are incorporated to control the potential year-effects.

Table 4.8 shows the estimation result for the effects of the alliances on schedule delay time. Although the schedule delay times are generally reduced due to the alliances, only the coefficients of KLM/NW and LH/UA are estimated as significant. The combination of their existing networks with better schedule coordination enables the "complementary" alliance partners to feed more connecting traffic to each other than before the alliance. The partners are also able to offer a higher frequency service to passengers by taking advantage of codesharing operations. As a result, the partners can increase flight frequencies and thus decrease passengers' schedule delay times.
TABLE 4.8 Effects of the Alliances on Schedule Delay Time

<table>
<thead>
<tr>
<th>Variables</th>
<th>BA/USAir (1)</th>
<th>BA/USAir (2)</th>
<th>DL/SN/SR (1)</th>
<th>DL/SN/SR (2)</th>
<th>KLM/NW (1)</th>
<th>KLM/NW (2)</th>
<th>LH/UA (1)</th>
<th>LH/UA (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-alliance</td>
<td>-5.78 (-0.65)</td>
<td>-21.96 (-1.24)</td>
<td>0.62 (0.34)</td>
<td>-2.16 (-0.78)</td>
<td>-21.61 c (-3.51)</td>
<td>-16.69 a (-1.80)</td>
<td>-19.03 c (-5.90)</td>
<td>-27.06 c (-7.25)</td>
</tr>
<tr>
<td>Year 1991</td>
<td>4.23 (0.31)</td>
<td>3.99 (1.31)</td>
<td>10.78 (0.93)</td>
<td>-11.00 c (-2.95)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1992</td>
<td>-0.46 (-0.03)</td>
<td>10.46 c (3.95)</td>
<td>4.99 (0.43)</td>
<td>-10.79 c (-2.89)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1993</td>
<td>25.13 a (1.69)</td>
<td>10.42 c (3.41)</td>
<td>6.29 (0.54)</td>
<td>-10.34 c (-2.77)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1994</td>
<td>21.04 (0.96)</td>
<td>9.42 b (2.45)</td>
<td>-3.33 (-0.23)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>76.64 c (15.4)</td>
<td>70.61 c (7.29)</td>
<td>91.81 c (77.4)</td>
<td>84.74 c (39.2)</td>
<td>97.72 c (23.8)</td>
<td>91.80 c (10.5)</td>
<td>95.57 c (66.3)</td>
<td>103.61 c (39.3)</td>
</tr>
<tr>
<td>n</td>
<td>44</td>
<td>44</td>
<td>34</td>
<td>34</td>
<td>47</td>
<td>47</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>R²</td>
<td>0.01</td>
<td>0.10</td>
<td>0.01</td>
<td>0.42</td>
<td>0.22</td>
<td>0.25</td>
<td>0.42</td>
<td>0.55</td>
</tr>
</tbody>
</table>

(Notes)

Number in parentheses is t-statistic.

a: p-value < 0.1,  b: p-value < 0.05,  c: p-value < 0.01

On the other hand, the coefficients of the BA/USAir and DL/SN/SR alliances are estimated as insignificant. The BA/USAir insignificance may be related to the one-sided codesharing by BA on USAir's flights within the US. In fact, BA has increased "actual" flight frequency on the North Atlantic routes to which USAir feeds its domestic traffic. However, unlike the other alliances, the codesharing effect on flight frequency never occurs
on the North Atlantic routes for this alliance because of the one-sided codesharing. Lack of the codesharing effect on the trans-Atlantic routes causes the coefficient of BA/USAir to be insignificant. The reason for the DL/SN/SR insignificance is the nature of the "shutdown" parallel alliance. Although the partners are able to maintain the same number of flights through codesharing effect, they in effect decrease their combined flight frequency.

4.6 EFFECTS OF ALLIANCES ON PARTNERS' STOCK VALUES

In this section, we measure the effects on alliance partners' stock values of the announcement of a new strategic alliance and of the operation of that alliance. For convenience, the effect of an alliance announcement on a partner's stock value is referred to as the "announcement effect," and the effect of the alliance operation on the partner's stock value as the "operation effect," hereafter.

According to the efficient markets hypothesis, right after a new alliance is announced, there will exist abnormal changes in the partners' stock prices. However, the announcement effect may be obscure because of the characteristics of alliance announcements. In the early 1990s, many carriers had made lots of strategic announcements until they chose actual alliance partners. After the initial true announcement, alliance partners have released a sequence of small announcements extending their aligned routes during their post-alliance periods. If these successive announcements have been reflected

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24 For example, in September 1993, LH announced that it would soon choose either UA or AA as its partner (Aviation Week and Space Technology, September 13, 1993).
in the partners’ values, there may exist structural changes in their stock price trends during the post-alliance period. The structural changes in a partner’s stock price due to the alliance operation can be measured by comparing the partner’s pre- and post-alliance stock price trends. The announcement and operation effects are examined in Subsections 4.6.1 and 4.6.2, respectively.

4.6.1 Effects of alliance announcements on partners’ stock values

The announcement effects can be measured by the event-study methodology. The methodology has been applied to a variety of firm-specific and economy-wide events (For a review of event studies, see, for example, Campbell, 1997, pp.149-150).

We search for the exact announcement days of the four alliances under consideration in this chapter. The BA/USAir alliance was announced on July 21, 1992 (Economist, July 25, 1992). The KLM/NW alliance was announced a few days before November 21, 1992 (Business Week, November 30, 1992). From the September and October 1993 issues of Aviation Week and Space Technology, we infer that the LH/UA alliance was announced between September 13 and October 4, 1993. The announcement day of the DL/SN/SR alliance is not available. The event-window period is defined as the period starting from a week before the announcement week to a week after the announcement week. The estimation-window period is defined as the announcement year excluding the event window period. The announcement year (week) is the year (week) in which the

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25 The event-window period for each carrier is as follows: for BA and USAir, three weeks (July 15, 22, and 29, 1992), for KLM, three weeks (November 11, 18, and 25, 1992), and for LH, five weeks (September, 7, 14, 21, 28, and October 5, 1993), respectively.
announcement of a new alliance was released.

We collect from Datastream weekly financial market data including alliance partners' stock prices and stock price returns, and their national transport composite indices. The Datastream database provides comprehensive, historical information on over 140,000 securities, allowing one to carry out a time-series analysis. Since the stock prices of NW, SN, and UA are not available, we exclude these airlines from the analysis.

We assume that the return of a firm's security is a function of the return of the market portfolio during the event-window and estimation-window periods:

\[ R_t = \beta_0 + \beta_1 M_t + \epsilon_t \quad \text{for } t = 1, 2, \ldots, T \]  \hspace{1cm} (4.17)

where \( R_t \) is the return of its security at time \( t \), \( M_t \) is the return of the market portfolio at time \( t \), and \( \epsilon_t \) is a random error term with \( E[\epsilon_t] = 0 \) and \( \text{Var}[\epsilon_t] = \sigma^2 \). \( \beta_0 \), \( \beta_1 \), and \( \sigma^2 \) are the parameters of the model. Using matrix notation, (4.17) can be rewritten as

\[ R = M \beta + \epsilon \]  \hspace{1cm} (4.18)

where \( R \) is a T-by-1 vector, \( M \) is a T-by-2 matrix, \( \beta \) is a 2-by-1 vector, and \( \epsilon \) is a T-by-1 vector.

\[ \text{The following transport composite indices are used for each airline: Dow Jones Transport Index (DJTRSPPT) for the US carriers, Financial Times Actuaries Shipping & Transport Index (FTASHPT) for BA, Amsterdam CBS Transport Index (CBSTRNS) for KLM, Frankfurt Allgemeine Zeitung Trade, Communication & Transport Index (FAZTCOM) for LH, and Swiss Performance Transport Index (SITRANS) for SR. The FTASHPT and CBSTRNS indices are not available after January 1994.} \]

\[ \text{The transport composite index (TCI) is used as a proxy of the market portfolio. Of course, the market composite index (MCI) can be used as the proxy. We found a highly positive correlation between TCI and MCI for each country under consideration.} \]
Chapter 4. Empirical Analysis: Cases in North Atlantic Markets

For each carrier under consideration, we conduct the regression for the estimation-window period. Let $e_i = R_i - m_i \hat{\beta}$ denote the abnormal return of the partner's security at week $t$ in the event-window period. $m_i = [1, M_i]'$ is a 2-by-1 vector. Assuming that the random error $e_i$ is drawn from a normal distribution, it can be shown that

$$
\sum_{t=1}^{N} e_t \sim N(0, \frac{1}{N^2} \sum_{t=1}^{N} \sigma^2_{e_t})
$$

(4.19)

where $Var(e_t) = \sigma^2_{e_t} = \sigma^2_\epsilon [1 + m_i' [M'M]^{-1} m_i]$, and $N$ is the number of the weeks included in the event-window period (For the derivation of (4.19), see Appendix C). Thus,

$$
\frac{\sum_{t} e_t}{\left[ N^{-2} \sum_{t} \sigma^2_{e_t} \right]^{1/2}} \sim t_{N-2}.
$$

(4.20)

We can use this statistic to test the null hypothesis that the announcement of an alliance has no impact on the partner's normal return.

Table 4.9 shows the estimation and test results. All $\beta_1$ coefficients are estimated as positive and significant, implying a positive relation between a partner's return and the industry return.

Similarly to Ross (1984), we also estimated (4.17) with the interactive term $M_i \cdot POST$ where POST is a dummy variable equal to one from the announcement week on so as to test the null hypothesis that the announcement of an alliance does not change the partner's $\beta_1$. For all four carriers, the coefficients on this interactive term were estimated as tiny and insignificant, leading us to conclude that the $\beta_1$ was stable for each carrier under study.
TABLE 4.9 Measured Abnormal Returns due to Alliance Announcements

<table>
<thead>
<tr>
<th></th>
<th>BA</th>
<th>USAir</th>
<th>KLM</th>
<th>LH</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_0$</td>
<td>0.0013 (0.25)</td>
<td>-0.0001 (-0.01)</td>
<td>-0.0045 (-1.07)</td>
<td>0.0018 (0.29)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>1.1936 c (7.83)</td>
<td>1.4888 c (4.88)</td>
<td>1.0319 c (7.67)</td>
<td>1.3042 c (4.10)</td>
</tr>
<tr>
<td>$\sigma_e^2$</td>
<td>0.0013</td>
<td>0.0035</td>
<td>0.0008</td>
<td>0.0016</td>
</tr>
<tr>
<td>T</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>47</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.56</td>
<td>0.34</td>
<td>0.56</td>
<td>0.27</td>
</tr>
<tr>
<td>$\sum e_t$</td>
<td>0.0863 b (2.51)</td>
<td>0.0522 (1.04)</td>
<td>0.1216 c (5.02)</td>
<td>0.0331 (1.31)</td>
</tr>
</tbody>
</table>

(Notes)
Number in parentheses is t-statistic.
a: p-value < 0.1, b: p-value < 0.05, c: p-value < 0.01

For all carriers, the sums of the abnormal returns during their respective event-window periods (i.e., $\sum e_t$'s) are estimated as positive, ranging from 3.3 per cent (LH) to 12.2 per cent (KLM). But, the test statistics shown in (4.20) are estimated as significant only for BA and KLM. This leads us to conclude that there exist abnormal returns in the stock values of BA and KLM following the announcement of the respective alliances.

To make sure the analysis is robust, we shorten the estimation-window period\(^{29}\) and carry out the same analysis for each carrier. Table 4.10 provides the results of this analysis.

---
\(^{29}\) The reduced estimation-window period is the period starting from three months before the announcement month to either three months after the announcement month or the end week of the announcement year.
We can reach the same conclusions as those from Table 4.9.

**TABLE 4.10 Measured Abnormal Returns from the Reduced Estimation Window**

<table>
<thead>
<tr>
<th></th>
<th>BA</th>
<th>USAir</th>
<th>KLM</th>
<th>LH</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\beta}_0$</td>
<td>0.0001</td>
<td>-0.0087</td>
<td>-0.0098</td>
<td>-0.0015</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(-0.71)</td>
<td>(-1.11)</td>
<td>(-0.09)</td>
</tr>
<tr>
<td>$\hat{\beta}_1$</td>
<td>1.0756 c</td>
<td>1.5114 c</td>
<td>1.0000 c</td>
<td>1.6808 c</td>
</tr>
<tr>
<td></td>
<td>(6.16)</td>
<td>(3.80)</td>
<td>(4.31)</td>
<td>(2.01)</td>
</tr>
<tr>
<td>$\hat{\sigma}^2_e$</td>
<td>0.0014</td>
<td>0.0042</td>
<td>0.0014</td>
<td>0.0030</td>
</tr>
<tr>
<td>$T$</td>
<td>28</td>
<td>28</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.59</td>
<td>0.36</td>
<td>0.52</td>
<td>0.22</td>
</tr>
<tr>
<td>$\sum c_i$</td>
<td>0.0768 b</td>
<td>0.0777</td>
<td>0.1381 c</td>
<td>0.0373</td>
</tr>
<tr>
<td></td>
<td>(2.37)</td>
<td>(1.54)</td>
<td>(4.77)</td>
<td>(1.09)</td>
</tr>
</tbody>
</table>

(Notes)
Number in parentheses is t-statistic.
a: p-value < 0.1,  b: p-value < 0.05,  c: p-value < 0.01

**4.6.2 Effects of alliance operation on partners' stock values**

For the study of an alliance operation effect, weekly financial data points for one year before and after the formation of an alliance are collected for each carrier from Datastream.

The operation effect can be examined by measuring two structural changes: (i) a change in the magnitudes between the firm's pre- and post-alliance stock prices and (ii) a change in the slopes between its pre- and post-alliance stock price trends. A partner's stock
price will likely increase at the starting point of the alliance operation should the alliance be expected to positively affect the value of the partner in the near future. If in fact the partner performs better after the alliance formation, its stock price will increase more steeply during the post-alliance period than its increases during the pre-alliance period.

To have a better grasp of the idea, let us look at changes in each firm's stock prices. Figures 4.1 and 4.2 show changes in the stock prices of BA and USAir, respectively. The dotted vertical line in each figure demarcates between pre- and post-alliance periods of the BA/USAir alliance. The figures show an increase in the partners' stock prices right after the alliance formation, implying that the alliance formation may affect positive impacts on the partners' values. Figures 4.3 and 4.4 show the impacts of the DL/SR alliance on the partners' values. The partners' stock prices decrease for several months before the alliance, but their stock prices increase after the alliance. The impacts of the KLM/NW and LH/UA alliances on stock prices of KLM and LH are shown in Figures 4.5 and 4.6, respectively. Notice that the stock prices of KLM and LH start increasing right after the dotted lines.

However, increases in partners' stock prices after alliances may be attributable to a cyclical economy effect. The transport composite index is likely to go up during the "good" economy, while it is likely to go down during the "bad" economy. In order to control the cyclical economy effect, we adjust each airline's stock price by dividing it by the corresponding transport composite index. Then, for each partner, we run the following regression to examine the impacts of the alliance operation on the stock prices of the partner:
FIGURE 4.1 Changes in British Airways stock prices

FIGURE 4.2 Changes in USAir stock prices
Chapter 4. Empirical Analysis: Cases in North Atlantic Markets

FIGURE 4.3 Changes in Delta stock prices

FIGURE 4.4 Changes in Swissair stock prices
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FIGURE 4.5 Changes in KLM stock prices

FIGURE 4.6 Changes in Lufthansa stock prices
\[
\frac{S_t}{TCI_t} = \gamma_0 + \gamma_1 TIME + \gamma_2 POSTAL_t + \gamma_3 (TIME - TIME^*) \cdot POSTAL_t + \epsilon_t \quad (4.21)
\]

where \( S_t \) is the partner's stock price at time \( t \), \( TCI_t \) is the corresponding transport composite index at time \( t \), \( POSTAL_t \) is a dummy variable indicating the post-alliance period, \( TIME \) is \( t \) at time \( t \), \( TIME^* \) is a fixed number indicating the starting point of the post-alliance period, and \( \epsilon_t \) is a random error term.

The (4.21) specification captures two structural changes occurring at the starting point of the post-alliance period. First, the coefficient of \( POSTAL, \gamma_2 \), represents an immediate jump of the stock price of the partner at the starting point of the alliance. If \( \gamma_2 \) is estimated as positive for a partner, stock market expects that the alliance will have a positive impact on the partner's stock value in the near future. Second, \( \gamma_3 \) captures a change in the slope of the partner's stock price trends between the pre- and post-alliance period. \( \gamma_1 \) and \( \gamma_1 + \gamma_3 \) indicate the slopes of pre- and post-alliance stock price trends, respectively. If \( \gamma_3 \) is estimated as positive for a partner's stock price trend, we can infer that the alliance affects the stock value of the partner in a positive way.

Table 4.11 provides the estimation results of (4.21). Let us first focus on the \( \gamma_2 \) estimates. On the one hand, the adjusted stock prices of USAir and SR are estimated to jump up at the starting points of their respective alliances. On the other hand, the adjusted values of BA and DL are estimated to jump down at the starting points of their respective alliances. The \( \gamma_2 \) coefficients are estimated as insignificant for KLM and LH. The stock
market seems to expect that the stock values of USAir and SR will be positively influenced by the BA/USAir and DL/SR alliances, respectively, while those of BA and DL will be negatively influenced by the respective alliances.

**TABLE 4.11 Changes in Magnitudes and Slopes of Adjusted Stock Prices**

<table>
<thead>
<tr>
<th></th>
<th>BA</th>
<th>USAir</th>
<th>DL</th>
<th>SR</th>
<th>KLM</th>
<th>LH</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_1$</td>
<td>0.011 c</td>
<td>-0.005 c</td>
<td>-0.023 c</td>
<td>0.037</td>
<td>-0.067 c</td>
<td>0.013 c</td>
</tr>
<tr>
<td></td>
<td>(2.79)</td>
<td>(-4.23)</td>
<td>(-12.95)</td>
<td>(1.23)</td>
<td>(-4.64)</td>
<td>(12.81)</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>-1.754 c</td>
<td>0.392 c</td>
<td>-0.318 c</td>
<td>4.598 c</td>
<td>-0.982</td>
<td>-0.027</td>
</tr>
<tr>
<td></td>
<td>(-9.68)</td>
<td>(7.63)</td>
<td>(-4.09)</td>
<td>(3.50)</td>
<td>(-1.60)</td>
<td>(-0.65)</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>0.064 c</td>
<td>-0.007 c</td>
<td>0.020 c</td>
<td>0.112 c</td>
<td>0.135 c</td>
<td>-0.006 c</td>
</tr>
<tr>
<td></td>
<td>(10.56)</td>
<td>(-3.88)</td>
<td>(7.77)</td>
<td>(2.57)</td>
<td>(6.70)</td>
<td>(-4.19)</td>
</tr>
<tr>
<td>$\gamma_1 + \gamma_3$</td>
<td>0.075 c</td>
<td>-0.011 c</td>
<td>-0.003 c</td>
<td>0.149 c</td>
<td>0.068 c</td>
<td>0.007 c</td>
</tr>
<tr>
<td></td>
<td>(74.60)</td>
<td>(-39.65)</td>
<td>(-7.35)</td>
<td>(20.11)</td>
<td>(19.47)</td>
<td>(28.77)</td>
</tr>
<tr>
<td>$\gamma_0$</td>
<td>10.081 c</td>
<td>1.165 c</td>
<td>4.989 c</td>
<td>87.717 c</td>
<td>39.258 c</td>
<td>1.776 c</td>
</tr>
<tr>
<td></td>
<td>(80.22)</td>
<td>(32.68)</td>
<td>(89.70)</td>
<td>(93.61)</td>
<td>(89.01)</td>
<td>(58.84)</td>
</tr>
<tr>
<td>n</td>
<td>105</td>
<td>105</td>
<td>105</td>
<td>105</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.73</td>
<td>0.47</td>
<td>0.90</td>
<td>0.69</td>
<td>0.35</td>
<td>0.88</td>
</tr>
</tbody>
</table>

(Notes)
Number in parentheses is t-statistic.
a: p-value < 0.1,  b: p-value < 0.05,  c: p-value < 0.01

The $\gamma_3$ estimate reflects an "actual" performance change of the partners due to an alliance. All $\gamma_3$ coefficients are estimated as significant. The increases in the stock prices
For example, for SR, $\gamma_1$ and $\gamma_2$ are estimated as 0.037 and 0.112, respectively. The stock value of SR increased at the 0.037 slope for one year before the DL/SR alliance, while that increased at the 0.149 slope for one year after the alliance. For DL and KLM, $\gamma_1$'s are estimated as negative, but $\gamma_3$'s are estimated as positive. This implies that their stock prices started increasing right after their respective alliances. For USAir and LH, $\gamma_3$'s are estimated as negative, implying that the post-alliance performances of USAir and LH are lower than stock market expectation. Another reason for LH's negative $\gamma_3$ may be related with the transport composite index used for LH. The index includes not only the Transport industry, but also the Trade and Communication industries (see footnote 26). The latter industries contain high-tech companies which tend to be more cyclical than airlines.

### 4.7 EFFECTS OF ALLIANCES ON PARTNERS' TRAFFIC

Alliance partners are likely to increase their traffic on alliance routes after the alliance, if they coordinate very well and if they maintain their respective frequencies. The next question naturally arises: Does an alliance partner increase traffic on alliance routes more than its traffic increases on non-alliance routes? By the non-alliance routes, we refer to the routes on and/or beyond which there is no coordination between partners such as codesharing and block space sales.

Each carrier's traffic on alliance routes may increase more than traffic increases on non-alliance routes should its partner feed traffic from various cities not onto the non-
alliance routes, but onto the alliance routes. For example, BA provided non-stop services between 10 US gateways and London in late 1992. According to the February 1994 issue of OAG (post-alliance period), five of the ten gateways were connected to USAir's domestic flights originated from various US cities: 1 city to Boston, 3 to Baltimore, 11 to Charlotte, 14 to Philadelphia, and 7 to Pittsburgh. Provided USAir has successfully fed its traffic onto BA's trans-Atlantic flights between these five gateways and London, increases in traffic on the five alliance routes are likely greater than those on the other five non-alliance routes.

Thus, to examine the effects of the alliances on the partners' traffic, we compare changes in traffic on alliance routes to those on non-alliance routes for each of the four major alliances. Basically, the routes in Table 4.4 are used for alliance routes. Twenty-five non-alliance routes are selected for the comparison. Table 4.12 shows North Atlantic alliance and non-alliance routes chosen for this study. Since the four alliances are formed in either 1993 or 1994, traffic changes in years 1993 and 1994 are computed for each of the alliance partners for each of the routes by using the ICAO's Traffic By Flight Stage.

Since a traffic change depends on the size of a route, we run the following regression with route dummy variables incorporated:

\[
\Delta Q_t = \delta_1 PTNA_t + \delta_2 Q_{92} \cdot Y_{94} + \sum \delta_j RTE_j + \epsilon_t \tag{4.22}
\]

where \( \Delta Q_t = Q_t - Q_{t-1}; \) \( PTNA_t = Q_{t-1} \) if an airline is in the post-alliance period at year \( t, \) zero

---

30 The Atlanta-Zurich and Cincinnati-Zurich routes are added in the set of alliance routes. Since a substantial amount of data is not available for these routes, we excluded them for the analysis of the effects on air fares and passenger volume.
otherwise; \( Y_{\text{all}} = 1 \) for year 1994, zero otherwise; and \( \text{RTE}_j = 1 \) for route \( j \), zero otherwise.

Note that \( \delta_1 \) represents the effect of an alliance on the partner's traffic and that it shows an average percentage of traffic changes on the alliance routes, after taking into account traffic changes on the non-alliance routes. \( \delta_2 \) represents changes in traffic between 1993 and 1994. For example, if \( \delta_2 \) is estimated as 0.01, this means that traffic increases in 1994 by 1 per cent of the year 1992 traffic.

**TABLE 4.12 Selected North Atlantic Alliance routes vs. Non-alliance routes**

<table>
<thead>
<tr>
<th>Alliance</th>
<th>NORTH ATLANTIC ROUTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA/USAir</td>
<td>ATL-LON, BOS-LON, BWI-LON, DAL-LON, LAX-LON, NYC-LON, ORL-LON, PHL-LON, SEA-LON, WAS-LON</td>
</tr>
<tr>
<td>KLM/NW</td>
<td>ATL-AMS, BOS-AMS, BOS-FRA, BOS-LON, BOS-PAR, DET-AMS, DET-FRA, DET-PAR, MSP-AMS, NYC-AMS, WAS-AMS, YMX-AMS, YVR-AMS, YYY-AMS</td>
</tr>
<tr>
<td>LH/UA</td>
<td>ATL-FRA, BOS-FRA, CHI-FRA, CHI-PAR, DET-FRA, LAX-FRA, LAX-LON, MIA-FRA, NYC-FRA, NYC-LON, SEA-LON, SFO-PAR, WAS-FRA, WAS-LON, WAS-PAR</td>
</tr>
</tbody>
</table>

(Notes)
1. The underlined routes are alliance routes.
2. City codes
Chapter 4. Empirical Analysis: Cases in North Atlantic Markets

The estimation results are provided in Table 4.13. Most of the coefficients of the alliance partner variables are estimated as positive and significant. The coefficient of BAA is estimated as 0.083 and significant. Due to USAir's traffic feeding, BA was able to increase traffic by 8.3 per cent more on its alliance routes than traffic increases on its non-alliance routes, during the post-alliance period.

The coefficients for SNA and SRA are estimated as positive and significant. It implies that due to the DL/SN/SR alliance, SN and SR increased traffic on their alliance routes by 39 per cent more and 28 per cent more, respectively, than traffic increases on their non-alliance routes, during the post-alliance period. On the other hand, the coefficient for DLA is estimated as positive, but insignificant. In fact, DL took advantage of its alliance with SN and SR by increasing its traffic on the alliance routes more than traffic increases on the non-alliance routes. However, it stopped providing non-stop services on some North Atlantic routes in 1994, resulting in decreased growth rate by 7.6 per cent (IATA, 1994). These two offsetting effects may cause the coefficient of DLA to be insignificant.

The coefficient of NWA is very big and significant. NW has been re-routing its traffic on major North Atlantic routes between its hubs, Boston and Minneapolis/St. Paul, and European cities since its alliance with KLM. Due to the re-routing, for example, traffic between Boston and Amsterdam increased by an average of 35 per cent of the 1992 traffic during the 1993-94 period, while that between Boston and Frankfurt, London, and Paris decreased by 9 per cent, 13 per cent, and 3 per cent, respectively, of the 1992 traffic during the post-alliance period. By reflecting NW's traffic decreases on the non-alliance routes,
### TABLE 4.13 Traffic increase on Alliance routes vs. That on Non-alliance routes

<table>
<thead>
<tr>
<th>Variables</th>
<th>BA/USAir</th>
<th>DL/SN/SR</th>
<th>KLM/NW</th>
<th>LH/UA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAA</td>
<td>0.083 (2.87) c</td>
<td></td>
<td>0.009 (0.23)</td>
<td>0.100 (3.23) c</td>
</tr>
<tr>
<td>DLA</td>
<td>0.174 (0.97)</td>
<td>0.082 (2.43) b</td>
<td>19451.0 (4.44) c</td>
<td>5326.0 (2.57) b</td>
</tr>
<tr>
<td>SNA</td>
<td>0.390 (2.81) c</td>
<td>10275.0 (-1.54)</td>
<td>-3989.2 (-1.27)</td>
<td>-4050.6 (-1.28)</td>
</tr>
<tr>
<td>SRA</td>
<td>0.279 (2.72) c</td>
<td></td>
<td>-45696.0 (-1.65)</td>
<td>10807.0 (-3.17) c</td>
</tr>
<tr>
<td>KLA</td>
<td></td>
<td>-124.6 (-0.04)</td>
<td>877.5 (0.23)</td>
<td>6430.5 (3.25) c</td>
</tr>
<tr>
<td>NWA</td>
<td></td>
<td>3743.8 (0.90)</td>
<td>-45696.0 (-1.65)</td>
<td>137.5 (0.04)</td>
</tr>
<tr>
<td>LHA</td>
<td></td>
<td>-10275.0 (-1.54)</td>
<td>-4050.6 (-1.28)</td>
<td>6879.5 (4.19) c</td>
</tr>
<tr>
<td>UAA</td>
<td></td>
<td>5326.0 (2.57) b</td>
<td>-10807.0 (-3.17) c</td>
<td>5285.8 (2.68) c</td>
</tr>
<tr>
<td>Q_{22} x Y_{54}</td>
<td>-0.002 (-0.09)</td>
<td>-0.063 (-2.31) b</td>
<td>-0.093 (-8.03) c</td>
<td></td>
</tr>
</tbody>
</table>

* indicates an alliance route.
Number in parentheses is t-statistic.

a: p-value < 0.1,  b: p-value < 0.05,  c: p-value < 0.01
TABLE 4.13 (Continued)

<table>
<thead>
<tr>
<th>Variables</th>
<th>BA/USAir</th>
<th>DL/SN/SR</th>
<th>KLM/NW</th>
<th>LH/UA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHI-ZRH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVG-ZRH *</td>
<td>975.2 (0.33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAL-LON</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DET-AMS *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DET-FRA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>734.4 (0.19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5155.0 (0.90)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DET-PAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAX-FRA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAX-GNV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAX-LON *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAX-ZRH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-8428.7 (-2.75) b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIA-FRA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSP-AMS *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYC-AMS *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYC-BRU *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYC-CPH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-7263.5 (-1.38)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-13622.0 (-2.74) c</td>
<td></td>
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(Notes)
* indicates an alliance route.
Number in parentheses is t-statistic.
a: p-value < 0.1,  b: p-value < 0.05,  c: p-value < 0.01
its traffic is estimated to increase more than 100 per cent on the alliance routes from the previous year traffic.

The coefficient of LHA and UAA are estimated to increase traffic by 10 per cent more and 8 per cent more, respectively, on their alliance routes than traffic increases on their non-alliance routes during the post-alliance period. Unlike the other alliances, this alliance allows relatively balanced traffic increases for the partners. Their powers within the alliance may be more balanced than those in the other alliances.

4.8 SUMMARY

This chapter builds a structural model where firms' profit maximization behaviour and market demand condition mutually affect each other. The structural model is applied to panel data of the seventeen trans-Atlantic alliance routes for the 1990-94 period to examines the effects on air fares and passenger volume of four strategic alliances: BA/USAir, DL/SN/SR, KLM/NW, and LH/UA. This chapter also examines whether or not service quality improves due to the alliances by comparing pre- and post-alliance schedule delay times. This chapter also investigates the effects of the alliances on the partners' stock values and traffic. The main findings of this chapter are as follows:

First, the BA/USAir, KLM/NW, and LH/UA alliances increase aggregate demands on the routes where these alliances occurred, respectively, during the post-alliance period. On the other hand, the DL/SN/SR alliance decreases aggregate demands on the alliance routes during the post-alliance period.
Second, the KLM/NW and DL/SN/SR alliances result in decreased the partners' air fares by 22 per cent and 19 per cent on their alliance routes, respectively, during the post-alliance period. They could lower marginal cost by taking advantage of economies of traffic density. Utilizing extra resources more effectively, the DL/SN/SR partners could reduce their combined cost on the alliance routes. Linking existing networks and codesharing operations, the KLM/NW partners increased load factor by 5 per cent during the post-alliance period.

Third, by comparing with- and without-alliance equilibria, we find that the equilibrium annual passenger volume increases by an average 35,998 passengers, while the equilibrium air fares decrease by an average of $41 on the alliance routes, and that consumers in the North Atlantic alliance markets are generally better off due to the alliances.

Fourth, we identify service improvement due to the alliances. In general, the schedule delay times are reduced during the post-alliance period. However, the schedule delay time is estimated to be statistically significantly reduced on the routes where either KLM/NW or LH/UA alliance occurred. Thus, the schedule delay time is significantly reduced only by complementary type of alliance.

Fifth, the partners' values are positively affected by the alliance announcement and operation effects. The positive announcement effects are estimated as significant only in the BA and KLM cases. However, the positive operation effects are estimated as significant for most of the carriers under consideration. For example, the adjusted stock prices of USAir and SR are estimated to jump up at the starting points of their respective alliances. The
stock prices of BA and SR are estimated to increase more steeply during their post-alliance periods than stock price increases during their pre-alliance periods. The stock prices of DL and KLM started increasing right after their respective alliance formations.

Finally, most of the partners have greater traffic increases on their alliance routes than those on their non-alliance routes. For example, LH/UA increased traffic by 10 per cent more and 8 per cent more, respectively, on their alliance routes more than traffic increases on their non-alliance routes during the post-alliance period.
CHAPTER 5. CONCLUSION

5.1 CONCLUDING REMARKS

Most governmental bilateral agreements do not promote growth in international aviation markets (see footnote 3 in Chapter 1). Indeed, the most serious impediments to the expansion of international aviation are restrictions in bilateral agreements. Air carriers cannot simply fly wherever they want and buy whichever carriers they like, owing to bilateral restrictions and foreign ownership laws. Airlines' temporary best solution to bilateral restrictions is probably to form strategic alliances with foreign carriers, until airline ownership laws are changed and international aviation markets are truly liberalized.

The main purpose of this thesis is to examine the effects of strategic alliances in the international aviation industry on market outcomes and welfare. To the best of our knowledge, this thesis is the first systematic study investigating the effects of strategic airline alliances using formal theoretical modelling and structural empirical estimation.

Chapter 2 reviews the past history of strategic alliances, examines the present status of the alliances, and discusses the future evolution of the alliances. Chapter 2 shows that the US and European governments have favoured strategic alliances for the purpose of facilitating competition among international carriers and increasing the nations' public benefit.

Based on a case study of forty-six alliances among the world's top-30 airlines, areas
of joint activities are identified. We find that degree of integration gets stronger in alliances involving equity investment, as compared to alliances without equity investment. Various economic and strategic incentives for airlines to join strategic alliances are also summarized in Chapter 2.

Based on the past history and current status of strategic alliances, Chapter 2 suggests that the present alliance race will continue and that major strategic alliances will become more stable. Consequently, it is expected that a limited number of future global networks will be formed by strategic alliances composed of airlines from each continent.

Chapter 3 analyzes different types of strategic alliances under general demand and cost specifications, showing that complementary and parallel alliances have different effects on total output and consumer surplus. Given a symmetry condition, the complementary alliance increases total output and decreases "full" price, resulting in increased consumer surplus. On the other hand, both types of parallel alliances are likely to decrease total output on the alliance route. Consumer surplus is likely to decrease as a result of the parallel alliances.

Chapter 3 finds sufficient conditions under which each type of alliance improves welfare. For the complementary alliance, post-alliance total welfare can increase if the alliance partners and non-partner are symmetric in demands and costs and if the partners can coordinate to the extent that they provide the same level of connecting services as the non-partner. For the parallel alliances, post-alliance total welfare can increase if the alliance shifts the partners' demand functions upward and if the positive direct effects of the demand
shifts dominate the negative indirect effects through the strategic substitutes condition.

Chapter 3 tests the theory of the effects of strategic alliances concerning each firm's outputs and total output. The test results are generally consistent with the theoretical predictions. The test results indicate that the partners' traffic and total route output increase due to the complementary alliance, while the partners' traffic and total route output decreases due to the parallel alliance.

Extreme types of strategic alliances are constructed in Chapter 3. In reality, most strategic alliances fall somewhere between these types. In Chapter 3, whether or not there are demand shifts due to alliances plays a key role in assessing the effects on total output. It appears to be an empirical question whether or not there are demand shifts due to alliances. To these ends, Chapter 4 conducts an empirical analysis on the effects of strategic alliances on market outcomes and welfare.

The methodology developed in Chapter 4 is an improvement over previous studies. Consistency is maintained between the derived model and econometric estimation. The methodology treats the endogenous variables (air fares and passenger volume) formally in a simultaneous framework involving some constraints. In addition, a markup term is explicitly handled when estimating the system of equations. Finally, the effects of alliances are measured in a proper way, after taking into account structural changes caused by the alliances. This requires one to include data for both pre- and post-alliance periods for estimating the model. Previous empirical studies on strategic alliances do not appropriately handle this issue.
Chapter 4 finds that structural changes occur in demand and price equations due to alliances. The BA/USAir, KLM/NW, and LH/UA alliances shift up the demand function on the respective alliance routes during the post-alliance period, whereas the DL/SN/SR alliance shifts down the demand function. We also find that only two alliances (KLM/NW and DL/SN/SR) significantly shift down their price equations on the respective alliance routes during the post-alliance period.

A counterfactual scenario analysis reports that the effects on passenger volume are consistent with the theory derived in Chapter 3: the complementary type increases passenger volume, while the shut-down parallel type decreases passenger volume. Without distinguishing alliance types, equilibrium annual passenger volume increases by an average of 35,998 passengers, while equilibrium air fares decrease, on average, by $41 on the alliance routes. These changes increase consumer benefits by $130 million, a 12 per cent increase over the without-alliance consumer surplus level during the post-alliance period.

By and large, schedule delay times are reduced during the post-alliance period, owing to the alliances. In general, the partners' stock values are positively affected by the announcement of alliances and by the operation of the alliances. Most of the partners have experienced greater traffic increases on alliance routes than those on non-alliance routes. These positive impacts on the partners' stock values and traffic may be reasons why the partners maintain their relationship.

These findings have some important policy implications. First, policy makers need to encourage alliance partners to coordinate beyond-gateways, in addition to the coordination
of between-gateways, for the sake of consumers. Chapter 4 shows that the coordination of between-gateways alone cannot increase demands. Second, government agents should be cautious before granting antitrust immunity to would-be parallel alliance partners, particularly to the "shut-down" parallel alliance partners. Since the partners are significant competitors in the same markets, competition may be reduced if they are able to integrate their operations with the protection of antitrust immunity. As a result, the parallel alliance reduces consumer surplus and is more likely to decrease total welfare. Third, after allowing strategic alliances, the agents need to monitor the partners' combined flight frequency. This monitor should be strengthened particularly for the parallel alliance type. Finally, the "restricted" international aviation market can become more competitive by approving more complementary alliances and promoting competition among alliance groups. This policy may have the potential of improving welfare.

5.2 DISCUSSION OF FUTURE RESEARCH

Chapter 3 implicitly assumes that a certain type of alliance is exogenously formed between two firms, simplifying the comparison between pre- and post-alliance situations for the type of alliance. Since the main purpose of this thesis is to examine the alliance effects on market outcomes and welfare, firms' strategic reactions are ignored in the present analysis. However, each firm may strategically respond to other firms' actions. For example, when firm 1 realizes that firms 2 and 3 are trying to form a complementary alliance, it may propose a parallel alliance to firm 2 (or firm 3) in order to prevent them
Chapter 5. Conclusion

from doing so. Each firm will calculate expected payoffs for each action. Introducing the strategic interactions among the "players" into the model would complicate the analysis, but it might capture dynamic characteristics of strategic alliances.

The models in Chapter 3 do not distinguish the "world" welfare into each nation's welfare. Governments may not support a strategic alliance unless the alliance brings benefits to their nations. They may not be concerned with changes in the "world" welfare due to the alliance. Although governments have supported strategic alliances, they still regulate their airlines to form strategic alliances with foreign carriers. The governments may play crucial roles in the analysis of the effects of strategic alliances.

In Chapter 3, we construct models from the profit maximization perspective. However, there may be other reasons for airlines to form strategic alliances. For example, suppose that the frequencies for two airlines are fixed on a route due to bilateral agreements between the countries having the airlines. If the number of passengers on the route has been dramatically increasing and if a substantial amount of time is required to amend the bilateral agreements, then the two airlines may form a strategic alliance until they can increase their respective frequencies. We leave the analyses as to the strategic interactions among firms, the role of governments, the separation of world welfare into nation welfare, and the short-term goal for future research.

Chapter 4 uses annual passenger data on each route. Although these are the best data available now, the data have a critical limitation. If a strategic alliance exists during a fraction of a year, then only the corresponding part of traffic increases on the alliance route
are attributable to the alliance. Since the data are annual data, it is impossible to disaggregate the entire increases into smaller part of traffic increases. Thus, it is desirable to obtain more disaggregated level data such as the US DOT's Origin-Destination Survey data. This survey is a 10 per cent random sample of all tickets that originate within the US on US carriers. The current problem with these data is that they do not contain information on passengers to and from the US when their entire trip is on foreign carriers. However, the US has demanded that foreign carriers aligned with US carriers report their trans-Atlantic codesharing operations since the second quarter of 1996. These data will be very useful for future research.

Since we estimate the system of equations using alliance routes only, the effects of strategic alliances may be overstated. If alliance partners re-route their traffic through alliance routes, the traffic on the alliance routes would increase while the traffic on non-alliance routes would decrease. The data base needs to include data for both alliance and non-alliance routes. Although it requires much a larger data base, the effects on market outcomes are accurately measured. Despite these limitations, we believe that this thesis provides a foundation for studying strategic alliance issues.
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References


Appendix A. Case description

APPENDIX A. CASE DESCRIPTION OF 46 STRATEGIC ALLIANCES

TYPE 3. INVESTMENT ALLIANCES

American Airlines (AA) - Canadian Airlines (CP) (April 1994)

The investment in CP is $190 million. AA gets 25% of CP's voting shares and 8.33% worth of convertible preferred shares, thus eventually reaching 33.3%. AA has a right to nominate 1/4 of the Board of Directors and veto power on appointment of a CEO. Furthermore, AA has veto power on annual business plan, and capital and financial plans.

Codesharing agreements on transborder North American routes started from June 1995. Some codeshared routes are between Vancouver and Miami, New York, and San Jose, and between Toronto and Chicago, Los Angeles, Salt Lake City, Palm Springs, Kansas City, Nashville, Raleigh/Durham, Albuquerque, Newark, Tucson and Detroit.

AA has provided CP with a range of services in accounting, data processing and communications, operations planning, pricing and yield management, international services, passenger services training and US originated reservations. The two carriers' FFPs are also linked.

The carriers received immunity status from the US DOT on June 7, 1996. Their immunity does not cover the route between Toronto and New York because the route is dominated by AA.

Air Canada (AC) - Continental (CO) (April 1993)

AC invested in CO is $235 million, comprising of $55 million in common shares, $30 million in non-voting preferred shares and the rest in debt placed with third parties. AC gets 24% of CO's voting shares and 27.5% of its equity. Air Partners, the joint investor, gets 41% of CO's voting shares and 27.5% of its equity. Furthermore, AC has 6 seats on CO's 18-seat Board of Directors.

AC cooperates with CO in the following areas: reciprocal ground handling; traffic feed and coordination of flight schedules; increasing AC flight frequencies to CO's hubs, Newark, Houston and Cleveland; linked FFPs; general sales services; sharing aircraft maintenance; joint purchasing and inventory sharing; and joint North American network plans.

British Airways (BA) - USAir (US) (January 1993)

BA invested $300 million in USAir (24.6% of US equity). The $300 million investment is in the form of preferred shares in which BA is paid a fixed interest rate of 7%. A further investment of $450 million over the next 4 years has been delayed because of USAir's precarious financial situation. BA also has 3 seats on USAir's 16-member Board of directors.

USAir is required to terminate any existing codesharing, marketing or similar agreements with any non-US airline. In order to comply with antitrust laws, USAir has divested all of its existing route authorities between the US and the UK to other US carriers.

They have implemented codesharing operations to only 52 US cities using Baltimore/Washington, Boston, Charlotte, Los Angeles, New York, Philadelphia, and Pittsburgh as gateway cities. BA has plans to extend codesharing operations to the entire USAir network. The US government wants to exchange this with more slots at the London Heathrow airport for US carriers, and to push for an open skies agreement with the UK.

At the end of 1993, BA wet-leased 3 B767-200ER from USAir to fly from Pittsburgh,
Baltimore, and Charlotte to the London Gatwick airport. They use USAir crews who provide service in BA uniforms. 44% of profits on these flights go to BA and 56% to USAir. The aircraft are flown in BA livery. Joint FFP between the partners.

**British Airways (BA) - Qantas (QF) (March 1993)**

BA gets 25% of QF's equity for Australian $665 million. BA has 3 seats on QF's 12 seats Board of Directors. BA has veto rights on CEO decisions.

They have signed a 10-year agreement covering such areas as joint marketing, joint FFPS and airport lounges, schedule coordination, product development (e.g. Global Explorer Program), bulk fuel purchasing, and aircraft ordering. QF will participate in BA's BABS computer reservation system. They have codesharing operations to 19 major cities in Europe, Asia, Africa, and Americas. Linkage points between BA and QF are likely to be in other continents rather than at Australian cities.

**Delta (DL) - Singapore Airlines (SQ) (1989)**

Although the partners had equity swapping in 1989, they did not codeshare until April 1995. SQ owns about 5% of DL and DL owns about 5% of SQ. They are both Global Excellence partners with SR, and have recently formed a joint purchasing company with SR that is based in Zurich with branches in Atlanta and Singapore.

The two partners have codesharing and block space agreements on SQ's Singapore-New York/JFK service via Europe. Together with SR, they purchase inflight amenities, duty-free goods, stationary, uniforms, and office and computer equipment.

**Delta (DL) - Swissair (SR) (September 1989)**

DL gets 4.5% of SR's equity and SR owns about 5% of DL's equity. Although the carriers had equity swapping in 1989, they did not extend their cooperation until January 1993. The two airlines have block-space and caduciary agreements on flights from Atlanta, Boston, Chicago, Cincinnati, Los Angeles and New York to Zurich, and flights from Los Angeles and New York to Geneva. DL has also codesharing and block-space agreements on SR flights from Zurich and Geneva to Frankfurt, Munich and Stuttgart.

The partners share terminal facilities in Atlanta, New York, Geneva, and Zurich. They have FFP cooperation, schedule coordination, and joint handling. On some routes, DL flight attendants are present on SR aircrafts.

They recently received approval from the US DOT for antitrust immunity with SN and OS in June 1996. The immunity will remain in effect for five years, with the restriction on the Atlanta-Zurich and Cincinnati-Zurich routes.

**KLM (KL) - Northwest (NW) (November 1992)**

KL gets 25% of NW's voting shares and 49% of its equity. KL and NW share a "Worldwide Reliability" logo on the fuselages of their planes, tickets, timetables, advertising materials and in-flight service amenities. Until September 1993, the two partners operated joint round-trip flights from Amsterdam to Minneapolis/St.Paul, Detroit and Boston. KL operated the route between Amsterdam and Detroit, while NW operated routes between Amsterdam and Minneapolis/St.Paul, and Boston. By doing so, they linked NW's domestic service from 88 interior US cities to 30 cities in Europe and the Middle East.
From September 1993, all KL flights on North Atlantic routes connecting to and from the US were operated as a joint venture with NW. They operate joint venture services from Amsterdam to a total of 11 US destinations. KL flies routes to and from nine of these: Detroit, New York, Chicago, Washington, Atlanta, Orlando, Houston, Los Angeles, and San Francisco. NW is flying routes to and from two of these as before. They received antitrust immunity from the US DOT in November 1993.

Qantas (QF) - Air New Zealand (NZ) (1990)
QF owns nearly 20% of NZ. Although this is an equity alliance, this alliance has not been going very well as the two partners constantly have disagreements. NZ is currently trying to buy Ansett Australia, but is facing difficulties from QF as it opposes NZ purchasing QF's competitor in Australia. Their disagreements have also led to the indefinite postponement of the open skies agreement between Australia and New Zealand.

Despite these disagreements, the two carriers are still cooperating with each other, code-sharing on trans-Tasman routes, especially between Christchurch/Wellington (New Zealand) and Sydney/Melbourne/Brisbane (Australia), and between Auckland and Melbourne. These routes use both QF and NZ aircrafts.

Swissair (SR) - Singapore Airlines (SQ) (1989)
DL, SR and SQ were the first trilateral alliance, signed in 1989. They exchanged minor equity with each other. Up to 5% of equity may be swapped between the three carriers. SR currently owns 4.6% of DL and 0.6% of SQ. The three carriers also coordinate schedules, and have FFP linkage. Joint handling between the partners also occurs.

TYPE 2. BROAD COMMERCIAL ALLIANCES

Air Canada (AC) - Lufthansa (LH) (June 1996)
The carriers formed a broad commercial alliance on June 15, 1996. AC flies the Calgary-Frankfurt route, while LH flies the Vancouver-Frankfurt route. This alliance provides AC access beyond Germany to Central and Eastern Europe, and allows LH to have access to Canadian cities beyond the gateway cities.

The two partners also have reciprocal participation in FFP, coordination of schedules, one-stop check-in, combined purchasing of on-board amenities, shared aircraft maintenance and cooperation on the development of information technology systems.

Air Canada (AC) - United Airlines (UA) (October 1992)
Increased connections between Toronto, Montreal, Calgary and Winnipeg via Chicago to other US points. Connections in Miami to South America, in San Francisco to southern Asia and South Pacific, and in Los Angeles. FFP cooperation. Joint advertising and promotions.

Continental (CO) - Alitalia (AZ) (June 1994)
Codesharing, joint flights, joint marketing and combined FFP on flights from the US cities to Rome and Milan via New York/Newark. AZ flights will likely connect to 140 US domestic stops and 40 points beyond the US. AZ uses a CO's DC-10 aircraft wet-leased from CO on the
codeshared Newark-Rome route.

**Delta (DL) - Sabena (SN) (January 1993)**

They have codesharing and block-space agreements on flights between Atlanta, Boston, Chicago, and New York and Brussels, and also on flights between the US gateways and several German cities via Brussels. DL operates daily nonstop Atlanta-Brussels service, while SN operates the rest, including flights between Brussels and German cities (Berlin, Dusseldorf, Frankfurt, Hannover, Hamburg, Munich, and Stuttgart).

DL buys seats on SN flights on the Boston-Brussels and Orlando-Brussels routes. Both link FFP. They just recently received approval from the US DOT for antitrust immunity with Swissair and Austrian Airlines in June 1996. The immunity will remain in effect for five years, with the restriction on the routes including the Atlanta-Brussels route. They also coordinate in many other areas such as having flight attendants from both airlines crewing the flight on New York/JFK-Brussels route.

**Delta (DL) - Virgin Atlantic (VS) (April 1994)**

DL has gained access to Heathrow by buying 10-15% of all seats on VS flights between London/Heathrow and Los Angeles, Newark, New York/JFK, and San Francisco, and on VS flights between London/Gatwick and Boston, Miami, and Orlando. The flights will carry both VS and DL flight numbers. The agreement also includes a FFP partnership.

DL will benefit as higher yield passengers prefer to use Heathrow rather than Gatwick. Virgin will also benefit from a strengthened agreement. Virgin passengers will benefit from better connections and improved pricing to domestic US points, and by allowing Virgin frequent fliers to redeem their air miles to any of the worldwide destinations being served by DL.

**Lufthansa (LH) - United Airlines (UA) (June 1994)**

So far, equity stake is not involved. LH has a wide range of codesharing agreement with United. Codesharing began June 1, 1994 with UA flights from Cleveland, Denver, Detroit, Indianapolis, and Minneapolis connecting in Chicago with LH service to Germany. In addition, codeshared flights to Germany are available from New Orleans, Orlando, Philadelphia, Phoenix, and Tampa via Washington, D.C. UA’s services from San Diego and Seattle connect with LH flights in San Francisco. In the second phase, 13 more cities are added. In Europe, UA places its designator code on flights through Frankfurt to 8 cities in Germany as well as Vienna.

They coordinate in the following areas: Participation of FFP; Use of departure facilities (LH uses UA departure facilities at Chicago O’Hare and LH also coordinates facilities with United as necessary at its Frankfurt hub and at other points); Service enhancements (one-stop check-in between any UA/LH or United Express/LH connection, and boarding passes and seat allocation are given for all legs of the flight at the first check-in point).

Both airlines have individual two party pacts with Thai Airways and Air Canada, respectively. The both airlines have recently received antitrust immunity from the US DOT. The immunity will last for five years, with certain restrictions on the Chicago-Frankfurt and Washington, D.C.-Frankfurt routes.

**Lufthansa (LH) - Thai Airways (TG) (October 1994)**

Their codesharing agreement, which began to come in effect in the third quarter of 1995,
Appendix A. Case description

includes connecting their hubs together (Frankfurt and Munich to Bangkok), linking their FFPs, and joint use of terminals. Interline connections will be provided to other major European and Asian destinations that are beyond their hubs. Their first codeshared flights are 14 flights per week from Frankfurt to Bangkok, and twice weekly flights from Munich to Bangkok which connect to Chiang Mai and Phuket.

They also offer shared passenger lounges and terminal facilities, advanced seat reservation and through check-in on codeshared flights. FFP participation is also involved and both separately have alliance agreements with United Airlines.

SAS (SK) - Lufthansa (LH) (February 1996)

They began codesharing after receiving formal approval from the European Commission. They are codesharing between seven cities in Germany (Frankfurt, Munich, Berlin, Dusseldorf, Hannover, Hamburg, and Stuttgart) and five cities in Scandinavia (Copenhagen, Stockholm, Oslo, Gothenburg, and Bergen).

They are currently expanding their caduciary services to other places in Europe, mainly Austria, France, Italy, Portugal, and Spain. They have linked their FFP programs together, and allow their customers to access the other partner's business lounges. Ground-handling service is also handled by the other partner in its home market, and they provide through check-in service to all their connections.

However, the LH/SAS alliance has been required to surrender up to eight daily slots per airport in Frankfurt, Dusseldorf, Stockholm, and Oslo to any airline in the European Economic Area.

SAS (SK) - Air New Zealand (NZ) (1990)

In March 1994, they have signed a three-year commercial agreement expanding their current cooperation. The pact involves a preferred partnership agreement in which the airlines will feed passengers into each other's services between Scandinavia, New Zealand and the South Pacific.

It will include the development of joint FFP, schedule connections at common gateways in the Southeast Asia, and initiatives regarding destinations, interline fare agreements and potential codesharing opportunities.

TYPE 1. SIMPLE ROUTE-BY-ROUTE ALLIANCES

American Airlines (AA) - Qantas (QF) (1986)


American Airlines (AA) - Singapore Airlines (SQ) (July 1996)

Codesharing on flight between Singapore and Chicago.

Air Canada (AC) - All Nippon Airways (NA) (September 1994)

AC currently acts as the general sales agent for NA in Canada. Joint use of ground facilities, coordination of flight schedules, codesharing and block space sales, and joint development of system.
Air Canada (AC) - Korean Air (KE) (September 1993)

The airlines have a codesharing agreement under which AC and KE buy 48 seats on each of their departures on the Seoul-Vancouver-Toronto route. Ground handling is performed by each respective carrier at their home base. Other than codesharing and block space sales, they also have freight block space agreements on the same route.

Air Canada (AC) - Swissair (SR) (October 1992)

The carriers started the alliance in 1992 by first having schedule coordination and codesharing on flights on the Montreal-Geneva, Montreal-Zurich, and Toronto-Zurich routes. They have now expanded their partnership to the Western Canada during the summer: codesharing and block space sales on Vancouver-Zurich and Calgary-Zurich. Also FFP participation and exchange of flight attendants.

Air France (AF) - Japan Airlines (JL) (May 1994)

The airlines operate three joint non-stop weekly services between Paris/CDG and Tokyo/Narita. Furthermore, they operate seven joint non-stop weekly services between Paris/CDG and Osaka/Kansai. Reciprocal passenger handling in Paris and Kansai. This joint services help mitigate the high costs associated with flying into Kansai airport. AF and JL already cooperate on the cargo front and are building, with LH, a joint terminal at NY/JFK.

Air France (AF) - Sabena (SN) (April 1992)

Block space agreement on the Paris-Brussels route.

Alitalia (AZ) - Canadian Airlines (CP) (November 1995)

Codesharing on the Rome-Toronto route with seven weekly flights. CP operates the flights during winter and spring, while AZ serves the route in the summer.

Canadian Int’l (CP) - Japan Airlines (JL) (April 1996)

Codesharing on CP flights on the Nagoya-Vancouver route. Block space agreement on certain CP domestic routes.

Canadian Int’l (CP) - Qantas (QF) (1991)

Codesharing on the Sydney-Honolulu route operated by QF flights, and Honolulu to Vancouver and Toronto operated by CP flights.

Canadian Int’l (CP) - Varig (RG) (October 1991)

Codesharing on the routes between Canada and Brazil, Argentina and Chile.

Delta (DL) - All Nippon Airways (NA) (June 1994)

They currently have a marketing alliance where reciprocal ground handling occurs in Japan, Los Angeles, and New York. They also plan to have a codesharing and block space agreements on 13 weekly flights between Los Angeles and Tokyo that is subject to government approval. They also plan to caduciary on the New York/JFK-Osaka/Kansai, Honolulu-Kansai, and Portland-Nagoya routes. The carriers envisage a relationship that would include cooperation in the following areas: (i) enhanced interlining of passengers and freight, (ii) schedule coordination to facilitate connections.
between the two carriers, (iii) enhancement of CRSs, (iv) sharing of facilities and passenger handling in jointly served cities, (v) participation in each airline's FFP.

**Delta (DL) - Korean Air (KE) (July 1995)**


**Delta (DL) - Varig (RG) (June 1994)**

The two airlines have codesharing and block-space agreement on the routes from Atlanta, New York/JFK, Miami, and Los Angeles to Sao Paulo and Rio de Janeiro. They use Varig-owned 767s. Varig will become a participant in Delta's FFP.

**Japan Airlines (JL) - Air New Zealand (NZ) (December 1989)**

JL used to own about 5% of NZ's shares, but has already sold them. The carriers still caduciary flights from Osaka/Kansai, Tokyo/Narita and Fukuoka to Auckland and Christchruch. The two partners also have FFP participation.

**Japan Airlines (JL) - KLM (KL) (April 1993)**

Codesharing on the Tokyo-Amsterdam-Madrid and Tokyo-Amsterdam-Zurich routes where JL operates the Tokyo-Amsterdam leg of the routes and KL operates Amsterdam-Madrid and Amsterdam-Zurich legs of the routes. These caduciary flights replace JL's non-stop flights from Tokyo to Madrid and Zurich.

**Japan Airlines (JL) - Thai Airways (TG) (1985)**

Joint operations from Bangkok to Nagoya, Fukuoka and Osaka/Kansai.

**Lufthansa (LH) - Varig (RG) (1993)**

Codesharing on Frankfurt-Rio de Janeiro and Frankfurt-Sao Paulo. General sales and marketing cooperation which involves joint FFP and through check-in.

**Malaysia Airlines (MH) - Canadian Airlines (CP) (November 1995)**

Codesharing on the Kuala Lumpur-Taipei-Vancouver route on Malaysian operated aircraft.

**Malaysia Airlines (MH) - Singapore Airlines (SQ) (June 1993)**

Joint shuttle on the Kuala Lumpur-Singapore route. They are founders of Passages FFP. Joint catering venture based in Madras, India and joint line maintenance operation at Hong Kong/Check Lap Kok.

**Malaysia Airlines (MH) - Virgin Atlantic (VS) (June 1995)**

Codesharing between the UK, Malaysia and Australia where MA operates flights between Malaysia and Australia and VS operates flights between the UK and Malaysia.
Appendix A. Case description

All Nippon Airways (NA) - USAir (US) (December 1990)
Block space agreement and connecting service to Orlando for NA's services to Washington/Dulles and New York/JFK. Reciprocal FFP participation.

Northwest (NW) - Air New Zealand (NZ) (March 1995)
FFP cooperation, shared airport facilities, joint fares from US cities to NZ's South Pacific destinations.

Air New Zealand (NZ) - Canadian Airlines (CP) (December 1990)
Both airlines have signed a simple agreement: joint marketing, codesharing and FFP cooperation on 10 flights a week between Canada and New Zealand, and Fiji.

Air New Zealand (NZ) - Korean Airlines (KE) (January 1994)
Codesharing and passenger block space agreement on the Seoul-Auckland route.

Qantas (QF) - USAir (US) (1994)
After QF pulled out of the San Francisco market, it made a codesharing pact with US for flights in the San Francisco-Los Angeles corridor.

SAS (SK) - Thai Airways (TG) (1987)
Connections from Bangkok to other major cities in the Far East Asia. Codesharing services on the Bangkok-Stockholm and Bangkok-Copenhagen routes.

United Airlines (UA) - Thai Airways (TG) (1994)
The carriers caduciary UA flights beyond Los Angeles to US domestic points, and on the Bangkok-Taipei-San Francisco and Bangkok-Hong Kong-San Francisco routes.
APPENDIX B. PROOFS FOR THE SHUT-DOWN PARALLEL CASE

This part provides the proofs of Propositions 4-4, 4-5, and 4-6. Each firm's pre-alliance profit function can be expressed as

\[ \Pi^{1b} = \sum_{k=AH}^{BH} Q_k^b \left[ d(Q_k^1, Q_k^3) - g(Q_k^1 + Q_k^3) + Q_k^1 \left( d(Q_k^1) - \sum_{k=AH}^{BH} g(Q_k^1 + Q_k^3) \right) - \sum_{k=AH}^{BH} C(Q_k^1 + Q_k^3) \right] \]

\[ \Pi^{2b} = Q_A^2 \left[ d(Q_A^1, Q_A^3) - g(Q_A^1 + Q_A^3) - C(Q_A^2) \right] \]

\[ \Pi^{3b} = Q_B^3 \left[ d(Q_B^1, Q_B^3) - g(Q_B^3) - C(Q_B^3) \right] \]

where superscript b stands for before-alliance. Using specifications (4.37)-(4.38) and solving the first-order conditions, we have the following pre-alliance quantities

\[ Q_{AH}^{1b} = Q_{BH}^{1b} = \frac{(\lambda^2 - 2\lambda + 2)\alpha - 4}{2(3\lambda^2 - 7\lambda + 3)} \]  \hspace{1cm} (B1)

\[ Q_{AB}^{1b} = \frac{(1 - \lambda)(3 + \lambda)\alpha - 12}{2(3\lambda^2 - 7\lambda + 3)} \]  \hspace{1cm} (B2)

\[ Q_{AH}^{2b} = Q_{BH}^{3b} = \frac{(2 - 5\lambda)\alpha - 4(1 - 3\lambda)}{2(3\lambda^2 - 7\lambda + 3)} \]  \hspace{1cm} (B3)

where \( \lambda = 2\delta + \mu \). It can be shown that the second-order conditions for each firms' profit maximization problem reduce to \( \lambda < 2/3 \). Since outputs and marginal revenues (costs) should be positive, \( \alpha \) is constrained such that \( 6(\lambda + 3) < \alpha < [6(1 - \lambda)][\lambda(5 - 4\lambda)] \) for \( 0 < \lambda < 2/5 \).

The shut-down parallel-alliance profits for alliance partners and firm 3 can be expressed as
Appendix B. Proofs for the shut-down case

\[ \Pi^{(1+2)p} = Q_{AH}^1 \left[ d(Q_{AH}^1) - g(Q_{AH}^1 + Q_{AB}^1) \right] + Q_{BH}^1 \left[ d(Q_{BH}^1 + Q_{AB}^1) - g(Q_{BH}^1 + Q_{AB}^1) \right] + Q_{AB}^1 \left[ d(Q_{AB}^1) - \sum_{k=AH}^{BH} g(Q_k^1 + Q_{AB}^1) \right] \]

\[ - \sum_{k=AH}^{BH} C(Q_k^1 + Q_{AB}^1), \quad \Pi^p = Q_{BH}^3 \left[ d(Q_{BH}^3, Q_{BH}^3) - g(Q_{BH}^3) \right] - C(Q_{BH}^3) \]

where superscript p stands for parallel alliance. Solving the first-order conditions for the shut-down parallel alliance yields the following parallel alliance solutions:

\[ Q_{AH}^{(1+2)p} = \frac{(\lambda^3 - 5 \lambda^2 + 11 \lambda - 6) \alpha + 2(\lambda^2 - 8 \lambda + 6)}{6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12} \] \hspace{1cm} (B4)

\[ Q_{BH}^{lp} = \frac{(\lambda^3 - 5 \lambda^2 + 6 \lambda - 4) \alpha + 2(\lambda^2 - 2 \lambda + 4)}{6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12} \] \hspace{1cm} (B5)

\[ Q_{AB}^{lp} = \frac{(1-\lambda)[(\lambda^2 - 6 \alpha - 2(5 \lambda - 12)]}{6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12} \] \hspace{1cm} (B6)

\[ Q_{BH}^{3p} = \frac{(2-\lambda)[(5 \lambda - 2) \alpha - 2(6 \lambda - 2)]}{6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12} \] \hspace{1cm} (B7)

Again, it can be shown that the second-order conditions reduce to \( \lambda < 2/3 \). From the positive outputs and marginal revenues constraints, \( \frac{6}{\lambda + 3} < \alpha < \frac{2 \lambda^2 - 16 \lambda + 12}{\lambda(4 \lambda^2 - 17 \lambda + 12)} \) for \( \lambda < \frac{2}{5} \).

Proof of Proposition 4-4. Using (B1)-(B6), we can calculate changes in the partners' output due to the shut-down parallel alliance:

\[ \Delta Q_{AH}^{(1+2)p} = Q_{AH}^{(1+2)p} - [Q_{AH}^{1b} + Q_{AH}^{2b}] = - \frac{(\lambda - 1)(5 \lambda^2 - 14 \lambda + 6)(2 - 5 \lambda) \alpha + 12 \lambda - 4}{(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)(3 \lambda^2 - 7 \lambda + 3)} \] \hspace{1cm} (B8)
Appendix B. Proofs for the shut-down case

\[ \Delta Q_{\text{AB}}^{lp} = Q_{\text{AB}}^{lp} - Q_{\text{AB}}^{lb} = -\frac{\lambda(1 - \lambda)[(5 \lambda^2 - 17 \lambda + 6) \alpha - 2(6 \lambda^2 - 20 \lambda + 6)]}{2(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)(3 \lambda^2 - 7 \lambda + 3)} \]  
(B9)

\[ \Delta Q_{\text{HH}}^{lp} = Q_{\text{HH}}^{lp} - Q_{\text{HH}}^{lb} = -\frac{\lambda^2(2 - \lambda)[(2 - 5 \lambda) \alpha + 2(6 \lambda - 2)]}{2(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)(3 \lambda^2 - 7 \lambda + 3)}. \]  
(B10)

Since the denominator of (B8)-(B10) is negative for \( \lambda < 2/5 \), the sign of these equations depends on the numerator. It can be shown that the numerator of (B8) is negative, while those of (B9) and (B10) are positive for the feasible \( \alpha \) and \( \lambda \). Similarly, we can calculate, using (B3) and (B7), changes in firm 3's output

\[ \Delta Q_{\text{HH}}^{3p} = Q_{\text{HH}}^{3p} - Q_{\text{HH}}^{3b} = \frac{\lambda^2[(2 - 5 \lambda) \alpha + 2(6 \lambda - 2)]}{2(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)(3 \lambda^2 - 7 \lambda + 3)} \]

which is negative for the feasible range. \( Q.E.D. \)

Proof of Proposition 4-5. Using (B1)-(B7), we can compute changes in the partners' profits and changes in firm 3's profit

\[ \Delta \Pi^{lp} = \Pi^{lp} - \Pi^{lb} = -\frac{I \alpha^2 + J \alpha + K}{4(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)^2(3 \lambda^2 - 7 \lambda + 3)^2} \]  
(B11)

\[ \Delta \Pi^{lp} = \Pi^{lp} - \Pi^{lb} = -\frac{L \alpha^2 + M \alpha + N}{8(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)^2(3 \lambda^2 - 7 \lambda + 3)^2} \]  
(B12)

\[ \Delta \Pi^{lp} = \Pi^{lp} - \Pi^{lb} = -\frac{\lambda^2(\lambda - 2)(12 \lambda^3 - 53 \lambda^2 + 68 \lambda - 24)[(5 \lambda - 2) \alpha + 2 - 6 \lambda]}{8(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)^2(3 \lambda^2 - 7 \lambda + 3)^2} \]  
(B13)

where \( I = 90\lambda^{10} - 942\lambda^9 + 3949\lambda^8 - 8041\lambda^7 + 6312\lambda^6 + 5352\lambda^5 - 16539\lambda^4 + 15333\lambda^3 - 6794\lambda^2 + 1344\lambda - 72 \),
Appendix B. Proofs for the shut-down case

\( J = -2(144 \lambda^9 + 1302 \lambda^8 + 4768 \lambda^7 - 8614 \lambda^6 + 5640 \lambda^5 + 7522 \lambda^4 - 19480 \lambda^3 + 17324 \lambda^2 - 7176 \lambda + 1152), \)

\( K = -4(324 \lambda^9 - 4302 \lambda^8 + 23973 \lambda^7 - 74128 \lambda^6 + 141439 \lambda^5 - 174420 \lambda^4 + 140005 \lambda^3 - 70648 \lambda^2 + 20292 \lambda - 2520), \)

\( L = 180 \lambda^{10} - 1344 \lambda^9 + 1592 \lambda^8 - 14019 \lambda^7 - 63462 \lambda^6 + 120822 \lambda^5 - 124872 \lambda^4 + 71846 \lambda^3 - 20996 \lambda^2 + 2064 \lambda + 144, \)

\( M = -2(2016 \lambda^9 - 22620 \lambda^8 + 104444 \lambda^7 - 256128 \lambda^6 + 357312 \lambda^5 - 276612 \lambda^4 + 96936 \lambda^3 + 5912 \lambda^2 - 14160 \lambda + 2880), \)

\( N = 4(648 \lambda^9 - 6300 \lambda^8 + 22218 \lambda^7 - 27160 \lambda^6 - 30210 \lambda^5 + 136392 \lambda^4 - 180338 \lambda^3 + 119176 \lambda^2 - 39768 \lambda + 5328). \)

It can be numerically shown that (B11) is positive while (B13) is negative for the feasible \( \alpha \) and \( \lambda \). The sign of (B12) varies depending on the value of \( \alpha \) and \( \lambda \). \( Q.E.D. \)

Proof of Proposition 4-6. From (B8), \( \Delta P_{AH}^e > 0 \). Thus, \( \Delta CS_{AH}^e < 0 \). Similarly, from (B9), \( \Delta P_{AB}^e < 0 \). Thus, \( \Delta CS_{AB}^e > 0 \). Using (B1), (B3), (B5), and (B7), we can calculate

\[
\Delta P_{BH}^e = P_{BH}^p - P_{BH}^b = \frac{\lambda^2 (1 - \lambda) [(2 - 5 \lambda) \alpha + 2(6 \lambda - 2)]}{2(6 \lambda^3 - 27 \lambda^2 + 34 \lambda - 12)(3 \lambda^2 - 7 \lambda + 3)}
\]

which is negative for the feasible range. Consequently, \( \Delta Q_{BH}^e > 0 \) and \( \Delta CS_{BH}^e > 0 \). \( Q.E.D. \)
APPENDIX C. MEAN AND VARIANCE OF ABNORMAL RETURNS

Consider the market model shown in (4.18) where the return of its security is a function of the return of the market portfolio:

$$R = M\beta + \epsilon$$  \hspace{1cm} (C1)

where \(R\), the security return, is a T-by-1 vector, \(M\), the market portfolio return, is a T-by-2 matrix, \(\beta\) is a 2-by-1 vector, and \(\epsilon\), the random error, is a T-by-1 vector. The random error is assumed to be

$$\epsilon \sim N(0, \sigma^2_e I)$$  \hspace{1cm} (C2)

where \(I\) is a T-by-T identity matrix. The Ordinary Least Squares estimator can be written as \(\hat{\beta} = (M' M)^{-1} M' R\). It is straightforward to show that \(\hat{\beta} - \beta = (M'M)^{-1} M' \epsilon\). Let us define the abnormal return vector as \(e = R - M\hat{\beta}\).

Suppose that the regression is conducted for the estimation-window period and then the abnormal returns in the event-window period are computed by using the regression. The abnormal return at time \(\tau\) in the event-window period can be expressed as \(e_\tau = R_\tau - M_\tau' \hat{\beta}\) where \(m_\tau = [1, M_\tau]'\) is a 2-by-1 vector. The expected value of \(e_\tau\) is zero since

$$E[e_\tau | M] = E[m_\tau' \beta + \epsilon_\tau - m_\tau' \hat{\beta} | M] = m_\tau' \beta + E[\epsilon_\tau | M] - m_\tau' \beta = 0.$$  \hspace{1cm} (C3)

The variance of \(e_\tau\) can be written as
Appendix C. Mean and Variance of abnormal returns

\[ \text{Var}[e_t | M] = \text{Var}[e_t - m_t^i(\hat{\beta} - \beta) | M] \]

\[ = \text{Var}[e_t | M] + \text{Var}[m_t^i(\hat{\beta} - \beta) | M] - 2 \text{Cov}[e_t, m_t^i(\hat{\beta} - \beta) | M] \]

By (C2), \( \text{Var}[e_t | M] = \sigma^2_e \). The second term of (C4) can be expressed as

\[ \text{Var}[m_t^i(\hat{\beta} - \beta) | M] = \text{Var}[m_t^i(M'MM^{-1}M't) | M] \]

\[ = m_t^i(M'M)^{-1}M't \text{Var}[e | M]M(M'M)^{-1}m_t \]

\[ = \sigma^2_e m_t^i(M'M)^{-1}m_t. \]

The third term of (C4) is zero since

\[ \text{Cov}[e_t, m_t^i(\hat{\beta} - \beta) | M] = E[(e_t - E(e_t))[m_t^i(\hat{\beta} - \beta) - E(m_t^i(\hat{\beta} - \beta))]' | M] \]

\[ = E[e_t(\hat{\beta} - \beta)'m_t | M] \]

\[ = E[e_t e'M(M'M)^{-1}m_t | M] = 0. \]

Substituting (C5) and (C6) into (C4), we have \( \text{Var}[e_t] = \sigma^2_e = \sigma^2_e[1 + m_t^i[M'M]^{-1}m_t]. \)

Therefore, \( E[\sum_{i=1}^{N} e_i | M] = 0 \) and \( \text{Var}[\sum_{i=1}^{N} e_i | M] = \frac{1}{N^2} \sum_{i=1}^{N} \sigma^2_e. \)