

1/2/96



**EUROPEAN UNIVERSITY INSTITUTE**  
**Department of Economics**

# **Intra-European Airline Competition: A Theoretical and an Empirical Analysis**

Giovanni Nero

Thesis submitted for assessment with a view to obtaining  
the Degree of Doctor of the European University Institute

Florence, December 1995

LIB  
387  
.714  
NER

EUROPEAN UNIVERSITY INSTITUTE



3 0001 0023 2145 5

HARVARD

387-714 NER







**EUROPEAN UNIVERSITY INSTITUTE**  
**Department of Economics**

# **Intra-European Airline Competition: A Theoretical and an Empirical Analysis**

Giovanni Nero

LIB  
387.714  
NER



The Thesis Committee consists of:

- Prof. David Encaoua, University of Paris I  
“ Ulrich Kohli, University of Geneva  
“ Stephen Martin, University of Copenhagen and EUI  
“ Jacques Pavaux, University of Toulouse  
“ Louis Philips, EUI, Supervisor ..



# Contents

<b>Acknowledgement</b>	<b>vii</b>
<b>Introduction</b>	<b>1</b>
<b>1 European Airline Regulation and Empirical Evidence of Some European Airlines Networks</b>	<b>6</b>
1.1 Introduction . . . . .	6
1.2 The Regulatory Environment . . . . .	7
1.2.1 The Ancient Regime . . . . .	7
1.2.2 The New Regime . . . . .	8
1.3 Empirical Evidence of some European Airlines Networks . . . . .	12
1.3.1 Preliminary Comments . . . . .	12
1.3.2 Methodology and Data . . . . .	14
1.4 Austrian Airlines (OS) Network's Characteristics . . . . .	16
1.4.1 Network Description . . . . .	16
1.4.2 Austrian Domestic Market . . . . .	19
1.4.3 OS's Intra-European Market . . . . .	20
1.5 Swissair (SR) Network's Characteristics . . . . .	23
1.5.1 Network Description . . . . .	23
1.5.2 Swiss Domestic Market . . . . .	25
1.5.3 The intra-European Market . . . . .	26
1.6 KLM (KL) Network's Characteristics . . . . .	29
1.6.1 Network Description . . . . .	29
1.6.2 Dutch Domestic Market . . . . .	31
1.6.3 The Intra-European Market . . . . .	32
1.7 SAS (SK) Network's Characteristics . . . . .	35
1.7.1 Network Description . . . . .	35
1.7.2 Scandinavian Domestic Market . . . . .	37
1.7.3 The Intra-European Market . . . . .	39
1.8 Conclusion . . . . .	44
1.9 References . . . . .	45
1.10 Appendix . . . . .	46

<b>2</b>	<b>A Structural Model of Intra-European Airline Competition</b>	<b>50</b>
2.1	Introduction . . . . .	50
2.2	Assumptions and Model Set-up . . . . .	51
2.3	The Collusive Agreements Solution . . . . .	56
2.4	The Noncooperative Solution . . . . .	60
2.5	The Collusive Versus the Noncooperative Solution . . . . .	63
2.6	The Merger Solution . . . . .	66
2.7	The Merger Versus the Noncooperative Solution . . . . .	71
2.8	Conclusion . . . . .	74
2.9	References . . . . .	75
2.10	Appendix . . . . .	77
2.10.1	Second Order Conditions for the Collusive Solution . . . . .	77
2.10.2	Proof of Proposition 1 . . . . .	77
2.10.3	Proof of Proposition 2 . . . . .	78
2.10.4	Second Order Conditions for the Noncooperative Solution . . . . .	78
2.10.5	Proof of Proposition 3 . . . . .	78
2.10.6	Proof of Proposition 4 . . . . .	79
2.10.7	Proof of Proposition 5 . . . . .	79
2.10.8	Second Order Conditions for the Merger Solution . . . . .	80
2.10.9	Proof of Proposition 6 . . . . .	80
2.10.10	Proof of Proposition 7 . . . . .	80
2.10.11	Proof of Proposition 8 . . . . .	81
<b>3</b>	<b>Third Package, Lack of Entry and Noncooperative Collusion in the European Airline Industry</b>	<b>85</b>
3.1	Introduction . . . . .	85
3.2	Lack of Entry in Intra-EU Airline Markets . . . . .	88
3.2.1	Reactions to the New Regulatory Environment . . . . .	88
3.2.2	Strategic Interactions in the Airline Industry . . . . .	92
3.3	The Model . . . . .	94
3.3.1	Assumptions and Model Set-up . . . . .	94
3.3.2	Specifications . . . . .	100
3.4	Results . . . . .	103
3.4.1	GAME I: Partial Liberalisation . . . . .	103
3.4.2	GAME II: Complete Liberalisation . . . . .	108
3.4.3	Illustration and Numerical Example . . . . .	113
3.5	Concluding Remarks . . . . .	114
3.6	References . . . . .	116
3.7	Appendix . . . . .	119
<b>4</b>	<b>Spatial Multiproduct Duopoly with Finite and Small (Enough) Reservation Price</b>	<b>121</b>
4.1	Introduction . . . . .	121
4.2	Spatial Competition and Models of Product Differentiation: Some Basic Definitions . . . . .	122

4.3	The Assumptions of the Spatial Setting . . . . .	124
4.4	Proof . . . . .	128
4.4.1	The Second Stage Price Equilibrium . . . . .	128
4.4.2	The First Stage Location Equilibrium . . . . .	128
4.4.3	The Scope Decision . . . . .	129
4.5	Conclusion . . . . .	133
4.6	References . . . . .	134
4.7	Appendix . . . . .	135
4.7.1	The Two Outlet Case . . . . .	135
4.7.2	The One Outlet Case . . . . .	136
<b>5</b>	<b>Spatial Multiproduct Pricing: Theory and Empirical Evidence on the Intra-European Duopoly Airline Markets</b>	<b>137</b>
5.1	Introduction . . . . .	137
5.2	Price Competition and Location Choice in Multiproduct Duopoly	139
5.3	Spatial Multiproduct Duopoly Pricing: The Two-Outlet Case . .	143
5.3.1	The Interlaced Outlet Equilibrium . . . . .	143
5.3.2	The Neighbouring Outlet Equilibrium . . . . .	145
5.3.3	Comparison of the Various Equilibrium Patterns in the Two- Outlet Case . . . . .	146
5.4	Spatial Multiproduct Duopoly Pricing: The Three-Outlet Case . .	148
5.4.1	The Interlaced Outlet Equilibrium . . . . .	148
5.4.2	The Neighbouring Outlet Equilibrium . . . . .	150
5.4.3	The Mixed Outlet Equilibrium . . . . .	152
5.4.4	Comparison of the Various Equilibrium Patterns in the Three- Outlet Case . . . . .	155
5.5	A Model for Comparing Prices Across Airline Markets with Diffe- rent Location Patterns . . . . .	158
5.5.1	Introduction . . . . .	158
5.5.2	The Theoretical Structure . . . . .	160
5.5.3	The Data and the Econometric Specification . . . . .	165
5.5.4	The Empirical Findings . . . . .	170
5.6	Concluding Remarks . . . . .	172
5.7	References . . . . .	173
5.8	Appendix . . . . .	177

..



# List of Tables

1.1	European Airlines Equity Alliances in 1993 . . . . .	11
1.2	Airlines' Key Statistics . . . . .	13
1.3	OS Total Departures and Capacity According to Origin .	16
1.4	OS Intra-European Departures and Capacity According to Origin . . . . .	17
1.5	Main Cities of OS's European Network . . . . .	18
1.6	Austrian Domestic Market . . . . .	19
1.7	Austrian Population . . . . .	19
1.8	Intra-European Market . . . . .	20
1.9	OS European City-pairs . . . . .	22
1.10	SR Total Departures and Capacity According to Origin .	23
1.11	SR Intra-European Departures and Capacity According to Origin . . . . .	23
1.12	Swiss Population . . . . .	24
1.13	Main Cities of SR's European Network . . . . .	25
1.14	Swiss Domestic Market . . . . .	26
1.15	Intra-European Market . . . . .	26
1.16	SR European City-pairs . . . . .	28
1.17	KL Total Departures and Capacity According to Origin .	29
1.18	KL Intra-European Departures and Capacity According to Origin . . . . .	30
1.19	Main Cities of KL's European Network . . . . .	30
1.20	Dutch Population . . . . .	31
1.21	Dutch Domestic Market . . . . .	32
1.22	Intra-European Market . . . . .	33
1.23	KL European City-pairs . . . . .	34
1.24	SK Total Departures and Capacity According to Origin .	35
1.25	Scandinavian Population . . . . .	36
1.26	SK Intra-European Departures and Capacity according to Origin . . . . .	36
1.27	Intra-European Market . . . . .	40
1.28	SK Domestic City-pairs . . . . .	42
1.29	SK Intra-European City-pairs . . . . .	43
2.1	Comparison of Noncooperative and Cartel Equilibria . . .	81
2.2	Comparison of Merger and Noncooperative Equilibria . .	82

2.3	<b>NSW<sup>M</sup> Versus NSW<sup>comp</sup></b>	82
3.1	<b>AEA Routes Operated within the EEA in Accordance with the Third Package.</b>	90
3.2	<b>Numerical Example</b>	113
4.1	<b>Analogy Between Space Location, Product Differentiation and Transport Scheduling</b>	124
4.2	<b>Comparison of the Equilibrium Values</b>	132
5.1	<b>Equilibrium Price Comparison</b>	147
5.2	<b>Comparison of the Equilibrium Values</b>	148
5.3	<b>Equilibrium Price Comparison</b>	155
5.4	<b>Comparison of the Equilibrium Values</b>	157
5.5	<b>Example of Location Pattern</b>	166
5.6	<b>Airlines and Markets in the Data Set</b>	177
5.7	<b>Descriptive Statistics, Obs=122</b>	178
5.8	<b>2SLS Coefficient Estimates (Model I), Obs=122</b>	179
5.9	<b>2SLS Coefficient Estimates (Model II), Obs=122</b>	180



# List of Figures

1.1	OS's European Network in 1993 . . . . .	47
1.2	SR's European Network in 1993 . . . . .	48
1.3	KL's European Network in 1993 . . . . .	49
2.1	Two Simple Linked H&S Networks . . . . .	52
2.2	Linear Demand and Consumer Surplus . . . . .	65
2.3	$NSW^{comp}-NSW^{car}$ . . . . .	83
2.4	$NSW^{comp}-NSW^M$ . . . . .	84
3.1	Three Linked H&S Networks with One Domestic Leg ( $N = 1$ )	96
3.2	Three Linked H&S Networks with Three Domestic Legs ( $N = 3$ ) . . . . .	97
3.3	Range of Equilibria for $\delta_c$ and $\delta_p$ under CASE I. . . . .	119
3.4	Range of Equilibria for $\delta_c$ and $\delta_p$ under CASE II . . . . .	119
3.5	Range of Equilibria for $\delta_c$ and $\delta_p$ when $F = F_0$ . . . . .	120
3.6	Range of Equilibria for $\delta_c$ and $\delta_p$ as a Function of $F$ . . . . .	120
4.1	The Two (Interlaced) Outlets Case . . . . .	126
4.2	The One Outlet Case . . . . .	130
4.3	Equilibrium in the One Outlet Case . . . . .	133
5.1	Symmetric Locations in the Three Outlet Case . . . . .	141
5.2	Interlaced Locations with two Outlets . . . . .	143
5.3	Neighbouring Locations with two Outlets . . . . .	145
5.4	Interlaced Locations in the Three Outlet Case . . . . .	149
5.5	Neighbouring Locations with three Outlets . . . . .	151
5.6	Mixed Locations with three Outlets . . . . .	153

..

# Acknowledgements

This dissertation originated in 1991 while I was a teaching assistant in the Economics department of the University of Geneva, Switzerland. I am particularly indebted towards Prof. Henry Loubergé and Prof. Luc Weber for encouraging me to undertake doctoral studies. One year later, the doctoral Programme provided by the European University Institute (EUI) in Florence, Italy, caught my intellectual curiosity. My work at the EUI has greatly benefited from Prof. Stephen Martin's lectures on Industrial Organization and from Prof. Louis Phlips's course in Applied Microeconomics Theory. These courses provided me with the necessary (and I hope sufficient) tools for completing a thesis. At the same time, these courses opened up for me a vast and fascinating field of research in the airline industry.

I am particularly indebted towards my supervisor at EUI, Prof. L. Phlips for encouraging discussions and valuable suggestions throughout the completion of this dissertation. I also thank Prof. L. Phlips for providing me with the opportunity to publish a shorter version of Chapter 2, Chapter 3 and Chapter 5 as four EUI Working Papers in Economics, ECO No. 94/14, ECO No. 95/5, ECO No. 95/41 and ECO No. 95/42, respectively. A special thanks is addressed to Prof. S. Martin for his detailed and pertinent remarks on earlier drafts of the different chapters of the dissertation. I should also mention my friends and colleagues A. Baniak, B. Boehnlein, H.-T. Normann, S. Nardelli and the participants of the Student and Micro Workshops at the EUI and the University of Geneva for their help and comments. Needless to say that all remaining errors are my own.

Every researcher in the department of Economics at the EUI knows the valuable work performed by its secretariat. The secretariat is not only a model of efficiency but also of kindness. Jacqueline and Jessica, thank you for taking care of me throughout my stay at the EUI.

Finally, I would like to thank the Swiss Federal Office for Education and Science (Bundesamt für Bildung und Wissenschaft) for its financial contribution to this dissertation.

Karen, thank you for your patience and love.

G.N.

Florence, Italy  
December, 1995.

# Introduction

In the last two decades, the airline industry has been the object of much scientific research among scholars and general interest among nonacademic people. In comparison to its share of GNP, this industry is certainly one of the most cited in the economic literature. Among the several reasons why the airline industry fascinates academicians, one major reason is that the 1978 U.S. airline deregulation offered a real, one-shot, economic experiment. Advocates and opponents of the economic deregulation could finally test their theories on the airline industry. In fact, as often happens when a complex system is submitted to a serious shock, the economic consequences of the U.S. airline deregulation have surprised economists in many aspects. Within a few years, competition in this industry induced, principally, network restructuring, mergers and higher concentration<sup>1</sup>. These major structural changes have been extensively discussed in the literature (see, for example, Levine [1987], Borenstein [1992]). As a result, it has been recognised that the modelling of this complex industry should incorporate specific details, such as the structure of an airline network or the structure of the markets in which the airline operates. Such details are important factors in explaining airlines' pricing behaviour and/or airlines' market power in a deregulated or liberalised environment. The following two quotations attest to this fact:

*"...Nothing in the academic literature on the basic economics of the airline business addressed route structure or suggested that it was a consequence of some other important feature of airline markets."*

*M.E. Levine [1987,p.411]*

and

*"...Because carriers produce their "output" by operating over a network, it stands to reason that the only way to examine the effects of regulation change on carrier service provision is by incorporating network detail."*

*A.F. Daughety [1985,p.476]*

---

<sup>1</sup>As a by-product of deregulation, U.S. airlines set up powerful informational networks called Computer Reservation Systems, and two loyalty-inducing devices called Travel Agent Commission Override Programmes and Frequent Flyer Programmes. These by-products have largely influenced the worldwide airline industry.

The first objective of this dissertation is to incorporate such ingredients into the analysis of airline economics. In particular, airlines are viewed as multiproduct firms operating over a network of city-pairs markets.

The second objective of the dissertation is to focus on the European airline industry, the main motivation being that it is currently undergoing a phase of liberalisation, started in 1988 and to be completed by 1997. Since the industry is still experiencing a transition phase towards its long-run equilibrium, it is beyond the scope of this dissertation to provide an assessment of the effects of the European airline liberalisation. This work first sketches a general picture of the regulatory environment faced by the industry and provides a detailed description of the key characteristics of some European airlines. This description allows me, in a second step, to model some aspects of intra-European airline competition<sup>2</sup>. Therefore, rather than studying the effects of the new regulatory measures, this dissertation principally analyses intra-European airline competition under the more liberal rules and in the light of structural features specific to this industry. The theoretical framework is the one used in Industrial Organization theory (see, *inter alia*, Tirole [1988], Martin [1993]). In particular, I assume that airline competition can be analysed within the oligopoly paradigm. The underlying assumption, throughout this dissertation, is that an airline's action is likely to affect [the competitive environment of] its rival(s).

This dissertation is composed of five chapters. Each chapter is structured around a main theme and possesses its specific introduction, thematic development and conclusion. The order of appearance of the chapters reflects the progress of my work. Although each chapter raises a distinct issue, I have tried, as far as possible, to relate the different issues throughout the dissertation.

Chapter 1, entitled '*European Airline Regulation and Empirical Evidence of Some European Airlines Networks*', is descriptive. It has two parts. In the first part, I briefly describe the regulatory environment which European airlines faced before 1988 and examine the more liberal rules introduced after 1988. The most important features of the Third Package (and its consequences on the air freedom rights) are highlighted. In the second part, I provide a detailed analysis of the key characteristics in terms of network structure, network size and market structure of some European airlines, based on observations in 1993. Although each carrier possesses its own characteristics, the empirical analysis reveals some common features which are particularly interesting: a) Flag-carriers typically operate hub-and-spoke networks, b) their domestic network is mainly a matter of monopoly, and c) most intra-EU city-pairs are still operated by the two flag-carriers designated by the old bilateral agreements. In the conclusion, it is argued that such an

---

<sup>2</sup>By intra-European airline competition, I mean international air (scheduled) services between European countries.

empirical analysis provides useful insights into the understanding and modelling of intra-EU airline competition.

Chapter 2 is entitled '*A Structural Model of Intra-European Airline Competition*'. It combines the empirical findings of Chapter 1 and Brueckner & Spiller's [1991] recent theoretical advancement in the analysis of competition and mergers in airline networks. Its aim is to explore a structural model of intra-European airline competition. Using a two countries/two airlines (flag-carriers) framework, three different competitive scenarios are analysed. These scenarios reflect the new EU competition rules. The results suggest that, when flag-carriers operate hub-and-spoke networks, the potential welfare gains arising from abandoning collusive practices are significant throughout the network. In addition, the model shows that, with increasing returns to density, a cross-border merger between two flag-carriers may increase the net social welfare (the profits of the industry plus consumers' surplus) throughout the network. Consequently, the threat of monopolisation through merger should not always be of primary concern to EU antitrust authorities.

Chapter 3 is entitled '*Third Package, Lack of Entry and Noncooperative Collusion in the European Airline Industry*'. Its aim is first to document the lack of entry observed in intra-EU airline markets during the first two years of liberalisation and to review the recent empirical research on strategic interactions in the U.S. airline industry. In a second step, I present a theoretical analysis of the most important market access rights provided by the Third Package. In particular, I analyse the strategic effects that arise from repeated interactions among oligopolists given the specific features of the airline industry. This work is intended to give some insights into why European flag-carriers seem reluctant to fully exploit the more liberal regulatory rules which provide larger entry opportunities into new EU markets. To this end, I present a model which shows under which conditions the European airline industry is likely to sustain a noncooperative "mutual forbearance" equilibrium. The results of this analysis suggest that with low fixed costs, complete liberalisation (i.e., seventh freedom+cabotage rights) is more likely to promote competition since a noncooperative collusive outcome is more difficult to sustain, *ceteris paribus*. A simple EU policy implication of this chapter could be stated as follows: Grant cabotage rights, i.e., complete liberalisation. If barriers to entry are significant, then work towards reducing fixed costs and institutional barriers.

The objective of Chapters 4 and 5 is to study multiproduct duopoly within the framework developed by Hotelling's [1929] seminal paper on spatial competition. In Chapter 4, entitled '*Spatial Multiproduct Duopoly with Finite and Small (Enough) Reservation Price*', I first define the basic concepts of spatial compe-

tition and product differentiation. Concomitantly, I provide an analogy between space location, product differentiation and transport scheduling, such that the framework developed can be applied to analyse some relevant features of intra-EU airline competition. In a second step, I construct an example which suggests that, with a finite and small (enough) reservation price, multi-outlet equilibria can emerge as the result of a two stage location-then-price game. This result contrasts with Martinez-Giralt & Neven [1988] who consider a perfectly inelastic demand. It confirms that the existence of a second outlet in spatial duopoly competition is sensitive to the assumption about individual demand curves.

Chapter 5, entitled '*Spatial Multiproduct Pricing: Theory and Empirical Evidence on the Intra-European Duopoly Airline Markets*', focuses on spatial multiproduct duopoly pricing. The theoretical implications of location patterns within the 'standard' spatial model allow me to investigate to what extent location patterns affect firms' pricing behaviour and market performance. Following Bensaïd & de Palma's [1994] terminology, I show that noncooperative Nash equilibrium prices are higher under a neighbouring location pattern than under an interlaced location pattern. In the three-outlet case, where a mixed location pattern may also arise, I show that an interlaced location yields the more competitive prices and is the socially more desirable pattern. In a second part, I test the predictions of spatial multiproduct duopoly pricing using data on intra-EU airline markets. I model intra-EU airline markets as an one-dimensional (horizontally) differentiated industry. On a given route, the location pattern now designates the scheduling of flights in the time domain. The principal empirical result suggests that the neighbouring location pattern hypothesis cannot be rejected with data on intra-EU airline markets. In effect, after controlling for the principal variables that affect intra-EU airline fares, I find that duopoly airline markets experience, on average, higher fares under neighbouring departure times. These results suggest that policy-makers and airport authorities should cautiously consider the implications of departure times for market power and social welfare when awarding slots to competing airlines.

## References

- BENSAÏD, B., and de PALMA, A., 1994, "Spatial Multiproduct Oligopoly," Working Paper No. 1994.8, University of Geneva, April.
- BORENSTEIN, S., 1992, "The Evolution of U.S. Airline Competition," *Journal of Economic Perspectives*, 6, pp.45-74.
- BRUECKNER, J.K. and SPILLER, P.T., 1991, "Competition and Mergers in Airline Networks," *International Journal of Industrial Organization*, 9, pp.323-342.

- DAUGHETY, A.F.**, 1985, "Transportation Research on Pricing and Regulation: Overview and Suggestions for Future Research," *Transportation Research Part-A*, 19, pp.471-487.
- HOTELLING, H.**, 1929, "Stability in Competition," *Economic Journal*, 39, pp.41-57.
- LEVINE, M.E.**, 1987, "Airline Competition in a Deregulated Market: Theory, Firm Strategy, and Public Policy," *Yale Journal on Regulation*, 4, pp.393-494.
- MARTIN, S.**, 1993, *Advanced Industrial Economics*, Oxford: Blackwell Publishers.
- MARTINEZ-GIRALT, X.**, and **NEVEN, D.**, 1988, "Can Price Competition Dominate Market Segmentation ?," *The Journal of Industrial Economics*, 36, pp.431-442.
- TIROLE, J.**, 1988, *The Theory of Industrial Organization*, Cambridge: MIT Press.

# Chapter 1

## European Airline Regulation and Empirical Evidence of Some European Airlines Networks

### 1.1 Introduction

This chapter is composed of two distinct parts. The aim of the first part of the chapter is to describe the regulatory environment faced by the European airline industry. To this end, I describe the regulatory environment the industry comes from and is heading towards. This description is presented in Section 1.2. In the second part of the chapter, I develop in Section 1.3 a methodology to analyse some European airlines' key characteristics, based on observations in 1993. These are, in particular, the network size, the network structure, the market structure and the degree of competition on city-pair markets. The empirical analysis is carried out for Austrian Airlines, Dutch KLM, Swissair and Scandinavian SAS through Sections 1.4-1.7. The choice of airlines/flag-carriers satisfies a double constraint. First, they present similar characteristics in terms of size, costs, quality of service, reputation, domestic institutional environment, etc.. Accordingly, one can say that these airlines form a homogeneous group within the class of middle-sized European flag-carriers. Second, all of them are, in the near future, serious candidates for mergers. Although each carrier possesses its own characteristics, the empirical analysis reveals some common features which are particularly interesting. The analysis emphasises the following features: a) Flag-carriers typically operate hub-and-spoke networks, b) their domestic network is mainly a matter of monopoly, and c) most intra-European [hereafter, intra-EU<sup>1</sup>] city-pairs are still operated by the two flag-carriers designated by the old bilateral agreements. Accordingly, such an empirical analysis should provide useful insights into the understanding and modelling of intra-EU airline competition. The conclusion in Section 1.8 explains

---

<sup>1</sup>While I was in the process of writing the dissertation, the European Community (EC) legally became the European Union (EU). For the sake of consistency, I stick to the EU terminology throughout the dissertation.



how this chapter could provide empirical support to further research in airline economics.

## 1.2 The Regulatory Environment

### 1.2.1 The Ancient Regime

The foundations of post-war international, and therefore intra-European, regulation of *scheduled* air passenger services date back to the Chicago Convention of 1944. In their concern to protect their sovereignty, each government preferred to enter into *bilateral* deals. These bilaterals specified the conditions under which intra-European air services were provided. Therefore, access to gateways, routes, capacity and fares ensued from these agreements. The main features of the regulated intra-European airline industry were typically:

1. Each European country possessed a wholly or partially publicly owned airline<sup>2</sup> called the flag-carrier. One airline from each country was allowed to operate services on intra-European routes. This was referred to as the so-called *single designation* rule. According to Button & Swann [1992] in 1987, out of 988 intra-EU routes, only 48 had multiple designation.
2. The capacity offered by each flag-carrier was restricted such that, generally, each country could enjoy 50 % of the traffic between the two countries. The so-called *fifth freedom right*, i.e., the ability to carry passengers between two countries by an airline of a third country on a route with the origin/destination in its home country, was an exception in the intra-European air services. We can mention that the division of the market was often accompanied by pools agreements in which the airlines shared the revenue in proportion to the capacity employed. Thus even if one airline obtained 60 % of the revenue and the other airline only 40 %, they would nevertheless split the proceeds equally<sup>3</sup>. These pools agreements took place under the patronage of the International Air Transport Association [IATA].
3. IATA set up a series of conferences where airlines discussed and coordinated fares on a bilateral basis, the resulting fare agreements being subsequently approved by governments. As we can see, IATA provided incentives to respect the traffic share. This is why it has been compared to a successful, authorised and coordinated (by the member states) cartel, composed of multiple concerted duopolists on international routes.
4. At the domestic level, the "pampered" flag-carrier holds considerable market power. In fact, most of the time, airlines had a monopoly license for

---

<sup>2</sup>British Airways being the exception since its privatisation in 1987.

<sup>3</sup>Because of passengers' time preferences, it could be the case that two identical but time differentiated flights generate different revenues.

scheduled traffic in their home country. It should be mentioned that bilateral agreements did not make provision for *eighth freedom rights* or so-called *cabotage rights*, i.e., the ability to carry passengers within a country by an airline of another country with the origin/destination in its home country. Consequently, competition in the domestic market was often limited to the flag-carrier and occasional regional airlines.

Within this regulatory framework, European airlines have established a network of intra-European routes<sup>4</sup>. For a number of reasons, not to be developed here, this *ancient regime* lasted in Europe until the late 80's (see, e.g., Button & Swann [1992] and Encaoua & Perrot [1991] for an excellent survey).

### 1.2.2 The New Regime

From 1988, as an attempt to promote competition in intra-EU air transport, the Commission gradually introduced three packages of measures, containing regulations concerning competition rules (their enforcement and permissible exemptions), fares, market access, and licensing<sup>5</sup>. The main features of the First Package were:

1. The introduction of a greater pricing freedom. However, very deep discount fares should be approved by States on the basis of official *double approval*, i.e., both sides would have to agree.
2. Capacity shares between States could slightly deviate from the traditional bilateral agreements 50/50 split up to a 40/60 split.
3. The principle of *multiple designation* supplants the single designation rule.
4. A limited attempt to open up the market to fifth freedom competition, since restrictions on capacity (30 % of the aircraft capacity) and route access (must involve a category-two airport) undermine its effective scope.

The Second Package is similar to the First. It reflects the European Commission's intention to progress toward liberalisation. To this end, pricing freedom is extended to very deep discount fares and the capacity share can be increased by 7.5 % points per year. Under certain conditions, fifth freedom competition is allowed up to 50 % of aircraft capacity. Of course, these packages represented a minimum degree of liberalisation that had to be accepted by all 12 EU members.

---

<sup>4</sup>Notice that given the continent's geographic characteristics and traffic rights described above, the European average flight is about 700 kilometres and most intra-European services are provided by direct flights.

<sup>5</sup>The First Package is referred to OJ L374, No 3975/87/EEC, 31.12.87. The Second Package, to OJ L217, No 2342,2343/90/EEC, 11.8.90. Finally, the Third Package is referred to OJ L240, No 2411/92/EEC, 24.8.92.

They did not preclude more flexible (liberal) agreements, such as the Anglo-Dutch bilateral agreement concluded in 1984. However, important provisions and temporary exceptions have been granted to States and airlines in order to make the transition toward the new regulatory environment easier. The more striking of these are the opportunity to discuss fares, to coordinate capacity and, in some cases, to share pool revenues. As mentioned by Button & Swann [1992, p.236]:

*... "Whilst airlines could collude, there was a hope that they would increasingly act individually."*

As predicted, the introduction of these two packages did not invert the tendency of European airlines to make agreements. Consequently, excepting in some routes where a third carrier has been able to enter effectively in the market and compete against the respective national incumbents<sup>6</sup>, fares did not fall spectacularly in intra-European routes<sup>7</sup>.

Finally, the Third Package, in force from January 1993, is supposed to bring the EU air transport industry<sup>8</sup> toward the single market and the standard indicated by the Treaty of Rome<sup>9</sup>(1957). To that end, the Commission provided for two important measures:

1. A complete price freedom is given to airlines, i.e., fares do not have to be approved by governments. However, special provisions are granted to States and/or the Commission to intervene against "excessive normal economy fares" and predatory pricing.
2. Fifth freedom and seventh freedom<sup>10</sup> competition are generalised. This implies that any EU certificated airline can operate air services between two countries.

---

<sup>6</sup>For example, the London-Amsterdam, London-Brussels and London-Paris routes. See Abbott & Thompson [1991] for an assessment of the impact of some bilateral liberalisations such as the one concluded between the United Kingdom and the Netherlands Civil Aviation Authorities.

<sup>7</sup>See Abbott & Thompson [1991], Betts [1991], Betts & Gardner [1992], Van de Voorde [1992].

<sup>8</sup>Actually, the States joining the European Economic Area (EU+EFTA) will work toward adopting the provisions of the Third Package as a group with a common timetable. According to the AEA Yearbook, more than 87% of air travel will take place wholly within the EEA boundaries.

<sup>9</sup>The Treaty of Rome articles related to these standards and applying here are the following: Article 3 aims at the creation of conditions of undistorted competition (stemming from, for example, protectionist attitude, subsidies, etc.). Article 52 provides for the free movement of enterprise (the so-called Right of Establishment), i.e., an established company should enjoy similar rights to nationals (no discrimination). Article 85 provides the EU with the power to ban cartel arrangements and/or tacit collusion (antitrust). Finally, Article 86 provides a prohibitory power in respect of abuses by firms in market dominating positions (emerging from a merger, for example). Notice that Article 90 applies these provisions in modified form to public enterprises. For more references, see Button & Swann [1992].

<sup>10</sup>Seventh freedom right is similar to fifth freedom right, but without the origin/destination's restriction.

While the second measure should seriously undermine the traditional 50/50 split of traffic stemming from the bilateral agreements, little is set up to promote domestic competition. In fact, cabotage competition (for example, the Belgian Sabena offering services on the Venice-Rome route) is allowed up to 50 % of aircraft capacity *if* the domestic leg is combined with a route to the home country. Complete cabotage freedom will be granted from April 1997. Moreover, the severe financial crisis European airlines have been undergoing since 1991<sup>11</sup> influenced the Commission to exempt temporarily en bloc two categories of agreement. These are as follows:

- Agreements concerning schedule coordinations, tariff consultations, joint operations of new less busy routes and slots allocation at airports.
- Agreements relating to the use of common Computer Reservation Systems [CRS].

Although these “safeguards”, especially the first category, could ultimately undermine the short run effects of liberalisation, they seem to be justified in the light of the industry specificities. In fact, it is now openly admitted that it would not be in the EU interests to mimic the U.S. airline deregulation experience (1978). In effect, most authors recognise the necessity to establish, in contrast, a “coordinated” competition in the European airline industry, and the Third Package seems to follow this pragmatic approach<sup>12</sup>. Clearly, it is too soon to assess what effects these new measures will have on the industry. But to the extent that airlines have financial troubles, it is difficult to imagine a sudden and dramatic drop in European air fares. By the same token, given the high start-up costs of a new route in Europe<sup>13</sup>, a rapid and large scale entry of new carriers in profitable intra-European routes seems unlikely to occur, so far<sup>14</sup>. Notice, however, that such a prudent attitude could also stem from strategic effects that arise from repeated interactions among a few oligopolists (see the concluding remarks in Section 1.8 and more specifically Chapter 3).

---

<sup>11</sup>Except British Airways.

<sup>12</sup>See, for example, Pavaux [1984], Encaoua & Perrot [1991].

<sup>13</sup>According to Betts & Gardner [1992], European airlines estimate the introduction of a new route to cost around £10-12 million. Airlines may renounce to exploit new entry opportunities if the present value of future profits after entry is less than zero.

<sup>14</sup>In some cases, airport slots constraints, undoubtedly, act as an entry deterrence or at least slow down fifth and seventh freedom competition progression.

Table 1.1: European Airlines Equity Alliances in 1993

<i>Airline</i>	<i>Ownership Structure</i>	<i>Subsidiaries/Trade Investments</i>
AER LINGUS (EI) (Ireland)	100 % Public	80.0 % Aer Turas Teoranta 25.0 % Futura 49.0 % Pegasus 100 % Aer Lingus Commuter
AIR FRANCE (AF) (France)	98.6 % Public	75.0 % Air Inter 95.0 % Air Charter 51.0 % EuroBerlin 37.6 % Sabena 40.0 % CSA 3.50 % Air Madagascar 12.8 % Air Mauritius 1.50 % Austrian Airlines 25.0 % Cameroon Airlines 6.25 % Corse Mediterranee 28.5 % Aeropostale 4.00 % Royal Air Maroc 5.60 % Tunis Air
ALITALIA (AZ) (Italy)	86.4 % Public 13.6 % Private	100 % ATI 45.0 % Avianova (through ATI) 45.0 % Eurofly 27.6 % Air Europe (through Eurofly) 30.0 % Malev
AUSTRIAN AIRLINES (OS) (Austria)	66.9 % Public 12.6 % Private shareholders 10.0 % Swissair 9.00 % All Nippon Airlines 1.50 % Air France	100 % Austrian Air Services 80.0 % Austrian Airtransport
BRITISH AIRWAYS (BA) (United Kingdom)	100 % Private	100 % Caledonian Airways 100 % British Asia Airways 100 % BA Regional 49.9 % TAT 49.0 % Deutsche BA 49.0 % GB Airways 31.0 % Air Russia 25.0 % Quantas 24.6 % USAir 49.9 % The Plimsoll Line (owner of Brymon European)
IBERIA (IB) (Spain)	99.8 % Public	100 % Aviaco 100 % Binter 100 % Viva Air 45.0 % Viasa 35.0 % Ladeco 30.0 % Aerolineas Argentinas
KLM (KL) (The Netherlands)	38.2 % Public 61.8 % Private	100 % KLM Cityhopper 80.0 % Transavia Airlines 40.0 % ALM Antilean 35.0 % Martinair 33.0 % D.A.T Wallonie 20.0 % Northwest 14.9 % Air UK
LUFTHANSA (LH) (Germany)	56.9 % Public 43.1 % Private	100 % Lufthansa CityLine 100 % Condor Flugdienst 100 % German Cargo Services 49.0 % EuroBerlin 40.0 % SunExpress 26.5 % Lauda Air 24.5 % CargoLux 13.0 % Luxair
OLYMPIC AIRWAYS (OA) (Greece)	100 % Public	100 % Macedonian Airlines

end of table.

SABENA (SN) (Belgium)	61.8 % Public 37.6 % Air France 0.60 % Others	71.4 % Sobelair 79.0 % DAT 49.0 % D.A.T Wallonic
SAS (SK) (Sweden, Denmark, Norway)	50.0 % Public (ratio 3:2:2) 50.0 % Private	51.0 % Linjeflyg (owner of 75.0 % of Swedair) 57.0 % Danair Copenhagen 37.5 % Grolandsflyg 40.0 % Airlines of Britan Holdings (owner of British Midland) 43.0 % Lan Chile 49.0 % Spanair
SWISSAIR (SR) (Switzerland)	20.4 % Public 71.6 % Private 5.00 % Delta Airlines 3.00 % Singapore Airlines	52.6 % Crossair (voting share) 58.4 % Balair (voting share) 52.0 % CTA (voting share) 10.0 % Austrian Airlines 5.10 % Delta Airlines 0.60 % Singapore Airlines
TAP Air Portugal (TP) (Portugal)	100 % Public	22.0 % Euroair

Source: Various, including Association of European Airlines Yearbook 1993, Panorama of EU Industry 1991/92/93, Airlines Annual Reports.

## 1.3 Empirical Evidence of some European Airlines Networks

### 1.3.1 Preliminary Comments

The gradual approach to liberalisation put forward by the Commission has given European airlines the opportunity to enhance their scale through direct mergers, acquisitions, joint ventures and, less directly, through cooperative agreements. As a consequence, these alliances create complex links involving European flag-carriers and regional or local carriers, and one has to take these links into account when inferring on networks. To illustrate this point, Table 1.1 documents the most important European airlines equity alliances and/or subsidiaries, such as can be observed in November 1993. It is important to notice that mainly all European flag-carriers, directly or indirectly, control a large number of regional airlines. Most of the time, these regional airlines are subsidiaries operating on behalf of the flag-carrier, even if the flag-carrier's name does not appear as such. Austrian Air Services, for example, is a regional carrier which operates essentially on Austrian domestic routes and which is used by Austrian Airlines to "feed" its main airport in Vienna. A misrepresentation of such a phenomenon, would provide a wrong picture of Austrian Airlines' effective network. From Table 1.1, it follows that the same conclusion can be drawn for almost every flag-carrier. In particular, the most striking cases are: ATI (Alitalia's subsidiary), Aviaco (Iberia's subsidiary), KLM Cityhopper (KLM's subsidiary), Lufthansa CityLine (Lufthansa's subsidiary), Austrian Air Services (Austrian Airlines' subsidiary). All of them are 100 % domestic subsidiaries of the flag-carriers. With these preliminaries in mind, one can more appropriately analyse the characteristics of a particular airline's network.

In this section, four European scheduled airlines networks are discussed. Austrian Airlines (OS), Swissair (SR), Dutch KLM (KL) and Scandinavian SAS (SK)<sup>15</sup>. Table 1.2 provides some key statistics for each flag-carrier.

Table 1.2: Airlines' Key Statistics

	OS	SR	KL	SK
Fleet	39	99	127	162
Employees	4'800	20'500	26'800	21'500
Destinations in Europe	48	72	71	88
Total Destinations	67	119	154	98
Passengers Europe (000)	2'264.2	4'919.0	5'258.8	8'313.3
Total Passengers (000)	2'643.8	7'481.8	9'883.1	18'588.1

Source: Airlines' Annual Reports, 1993 and AEA Yearbook 1994 (Subsidiaries included).

These airlines, although operating in different markets, all present to a certain extent similar characteristics in terms of size, (high) costs, quality of services, marketing philosophies, domestic institutional environment, geographic limitations, etc.. These, in turn, may explain why Swissair, Austrian Airlines and SAS participate to an "alliance" known as the European Quality Alliance. Moreover, recent negotiations about a merger involving these three airlines and KLM were proceeding<sup>16</sup>. The motivation to study these airlines is, therefore, straightforward. More generally, however, this empirical research could provide an analytical framework for modelling the European airline industry and for evaluating the new EU competitive rules. My aim is to show that OS, SR, KL and SK—and possibly many European airlines—are all characterised to a large extent, by the following three features:

1. The flag-carrier operates, typically, a *hub-and-spoke* [hereafter, H&S] network. This network is centred in its major (hub) airport. Airline hubbing has been described by various researchers in transportation studies (e.g., Kanafani [1981], Viton [1983], Kanafani & Ghobrial [1985]) and its importance for airline economics has been largely acknowledged<sup>17</sup>. Bauer [1987] provides the following definition of this practise<sup>18</sup> (p.13):

<sup>15</sup>This is the official airline code operator and, for the sake of brevity, I will use it when referring to one of these airlines.

<sup>16</sup>The project is known as ALCAZAR. At the moment of writing, however, these negotiations failed. Opportunities for a merger involving fewer partners are, however, still open at the moment. Actually, during the summer 1995, the Swiss SR has taken a 49% stake in the Belgian Sabena (SN), with a further option to fully control SN by 2000.

<sup>17</sup>Recently, economists have identified this phenomenon as one of the most important—and unexpected—consequences of U.S. airline deregulation (e.g., Levine [1987], Borenstein [1992], etc.)

<sup>18</sup>For another definition see, for example, Spiller [1989]. For a graphical exposition, see Oum & Tretheway [1990].

*... "A hub-and-spoke network, as the analogy to a wheel implies, is a route system in which flights from many "spokes" cities fly into a central "hub" city. A key element of this system is that the flights from the spokes all arrive at the hub at about the same time so that passengers can make timely connections to their final destination."*

It follows that to operate efficiently a H&S network, the airline must have access to enough gates and take-off and landing slots at its hub airport(s) in order to handle the peak level of activity. Clearly, every European flag-carrier has been able to establish such a network in its home basis airport.

2. The flag-carrier, after having correctly taken its subsidiary(ies) into account, has a quasi-monopoly of its national (domestic) market. In other words, domestic market dominance is a common feature to most EU flag-carriers<sup>19</sup>. Any consideration of cabotage rights, in cases where they have been introduced, do not alter the previous statement.
3. Flag-carriers share the access of most intra-European routes. This is due to two phenomena. Firstly, the multiple designation rule has not yet been able to turn into effective policy. Therefore, few countries have multiple airlines (from the same country) serving scheduled intra-European services<sup>20</sup>. As a consequence, a flag-carrier's domestic competitor is unlikely to serve intra-European routes on a network basis. Secondly, fifth and seventh freedom competition, although generalised since January 1993, have not yet been fully integrated into European airlines networks.

### 1.3.2 Methodology and Data

My aim is therefore to analyse these features using airlines networks data. These data are directly collected from airline official timetables and ABC World Airways Guides. These timetables provide a complete description of the flight routings offered by the scheduled airlines. In particular, they indicate the frequency, on a weekly basis, at which a given city-pair or market is served and aircraft types used to serve it. Because airlines, typically, publish two or three timetables per year, I have decided to focus the analysis on the latest data available, i.e., the Spring 1993 timetable<sup>21</sup>. The analysis, therefore, corresponds to a typical spring or summer week. However, since the airlines analysed are not particularly season sensitive—which would not be the case for *charter* carriers—it is reasonable to assume that the annual basis figures would not change the results.

---

<sup>19</sup>Market dominance is generally defined as a market share above 40% with no close rival (see, e.g., Scherer & Ross [1991]).

<sup>20</sup>The notable exception being the United Kingdom.

<sup>21</sup>Austrian Airlines, for example, provides two timetables per year. The first is published in March and covers the spring and summer months. The second is published in October and covers the autumn and the winter months. Moreover, since the ABC World Airways Guide is a monthly issue, I consider different months in order to cover the airline's timetable period.



Moreover, since the chapter is primarily concerned with intra-European competition, I have decided to focus the analysis on the European network. This means that I do not consider the entire world network<sup>22</sup>, but only a significant part of it<sup>23</sup>. For the four airlines, for example, about 64 % of the total cities served are within Europe and in 1993, 54 % of the total of scheduled passengers transported took place in Europe (see Table 1.2).

---

<sup>22</sup>In fact, the European airlines have always operated the most important intercontinental routes and it is evident that, although the European network is viable in itself, it has a largely complementary feeder function as well. ..

<sup>23</sup>Actually, I had to choose a satisfactory definition of the European market; I have decided to include EU, EFTA, the former East-European countries, Turkey and Cyprus. Consequently, it includes all Association of European Airlines'[AEA] members.

## 1.4 Austrian Airlines (OS) Network's Characteristics

### 1.4.1 Network Description

OS is the Austrian flag-carrier. Table 1.1 provided for the extent of OS's subsidiaries and/or trade investments. It appears that Austrian Air Services is a regional *scheduled* carrier, operating domestic (Austrian) routes on behalf of OS. In fact, the Austrian Air Services network is completely integrated in the OS's timetable. In airline jargon, Austrian Air Services is used by OS to "feed" its main airport in Vienna. To be effective, a "feeder" airline must coordinate its flight routings, i.e., network, and timetable in accordance to the one of the flag-carrier, in order to minimise scheduled delays for passengers continuing through Vienna to final destinations. It seems, therefore, natural to analyse both airlines as one (horizontally) integrated firm.

Table 1.3: OS Total Departures and Capacity According to Origin

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
VIENNA	489	72.7 %	49'746	83.8 %
GRAZ	51	7.6 %	3'258	5.5 %
LINZ	50	7.4 %	2'400	4.0 %
SALZBURG	50	7.4 %	2'400	4.0 %
KLAGENFURT	33	4.9 %	1'584	2.7 %
	673	100 %	59'388	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and OS official timetable.

Table 1.3 shows the total of the European departures (take off) and capacity offered by OS, in function of the (Austrian) city of origin<sup>24</sup>. The table puts clearly forward the importance of Vienna airport in OS operations. More than 72.7 % of total OS departures take place from Vienna. The capacity figure is even more striking, since almost 84 % of the seats are offered from Vienna<sup>25</sup>. Table 1.4 considers only intra-European flights, i.e., it excludes domestic flights. Table 1.4, not surprisingly, emphasises the importance of Vienna's international airport. Around 82 % of OS's intra-European departures take place there. This observation is the *first* network characteristic: OS operates a network centred at its major hub airport, i.e., Vienna. Other (regional) airports are principally used to "feed" this airport. The rationale for using a hub airport is to target passengers travelling between origins and (different) destinations for which traffic volume is not sufficient for frequent direct flights as, for example, Klagenfurt-Rome.

<sup>24</sup>Capacity is obtained by multiplying the departures by the number of aircraft seats. Capacity is, therefore, expressed in terms of seats and corresponds to the seats *offered* by OS. The capacity *sold* by OS is obtained by multiplying the capacity figure by the passenger load factor.

<sup>25</sup>Notice that the discrepancy observed between departures and capacity percentage figures, arises from the fact that larger aircraft are used in Vienna.

**Table 1.4: OS Intra-European Departures and Capacity According to Origin**

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
VIENNA	396	81.7 %	45'039	90.3 %
GRAZ	20	4.1 %	1'527	3.05 %
LINZ	34	7.0 %	1'632	3.25 %
SALZBURG	35	7.2 %	1'680	3.4 %
KLAGENFURT	0	0 %	0	0 %
	485	100 %	49'878	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and OS official timetable.

The above figures provide a rough indication of the extent of H&S network used by OS. In order to have a more precise measure of H&S operations, McShan & Windle [1989] suggest the following hubbing index ( $I_h$ ). This index simply measures the proportion of an airline's total departures leaving from the three percent most utilised airports (points served) in that airline's network<sup>26</sup>. Let us compute this hubbing index from OS's European network<sup>27</sup>. In order to implement it, I need to compute the total number of weekly departures carried out over the European (including domestic) network. OS's European network consists of 48 points or cities. The total number of departures accounts for 1'179. Table 1.5 describes the departures and capacity in the main cities of the network. From Table 1.5 it follows that Vienna and Zurich are the most important airports for OS, both in terms of departures and capacity<sup>28</sup>. This feature is very interesting since it stresses the importance of Zurich in OS's network, although it is an airport outside the country of origin. It also reflects the strategic alliance formed by OS and SR.

<sup>26</sup>One can argue that this choice is somewhat arbitrary, since there are no theoretical reasons for assuming that the proportion of an airline's departures leaving from the three percent most utilised airports is well-suited to capture the extent of hubbing. Similarly, it could be argued that a more appropriate index would measure the extent of coordinated banks of connecting flights operated in its main airports. However, according to McShan & Windle [1989], their rule corresponds closely with the results of identifying hubs intuitively. See Keeler & Formby [1994] for a different hubbing index.

<sup>27</sup>Therefore, our index will be a partial measure of McShan & Windle's hubbing index which considers the whole network. Given that our aim is the analysis and the comparison of European airlines' characteristics, the qualitative results obtained with the partial index should not significantly differ from those obtained using the original McShan & Windle's index. Moreover, it turns out that our partial index corresponds closely with the results of identifying European flag-carriers' hubs intuitively.

<sup>28</sup>Notice that the rank correlation between departures and capacity is not equal to 1. This discrepancy occurs because different types of aircraft are used. Larger aircraft and therefore, ceteris paribus, a larger capacity provided, can reverse the rank of departures, as is the case, for example, between Graz and Frankfurt.

Table 1.5: Main Cities of OS's European Network

FROM	WEEKLY DEPARTURES	FROM	WEEKLY CAPACITY
VIENNA	489	VIENNA	49'746
ZURICH	82	ZURICH	6'123
GRAZ	51	FRANKFURT	3'876
LINZ	50	LONDON	3'397
SALZBURG	50	GRAZ	3'258
FRANKFURT	47	COPENHAGEN	3'139

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and OS official timetable.

From Table 1.5, it is very easy to implement the hubbing index. In fact, the three percent criterion of the most utilised airports is 1.44 (3 % of 48). This means that OS's hubbing index,  $I_h^{os}$ , accounts for all Vienna's departures and 44 % of Zurich's departures.  $I_h^{os}$  would be

$$I_h^{os} = \frac{489 + (0.44)(82)}{1'179} = 0.44536. \quad (1.1)$$

This result implies the following remarks:

1.  $I_h^{os}$  would certainly be higher if the world-wide network had been considered. This arises because all OS's intercontinental flights originate in Vienna, contributing, therefore in the increase of the share of Vienna. We can notice that McShan and Windle [1989] obtained the following figures for the U.S. airlines in 1984: Their  $I_h$  ranges from 0.2593 (Piedmont) to 0.4659 (American Airlines), for an industry average equal to 0.3632. Undoubtedly, these figures would be higher today since, according to experts, the U.S. airlines have continued to adjust their networks throughout the 80s. In fact, it is a well established fact that the industry concentration started in mid 80s and stemming from numerous mergers and bankruptcies, permitted airlines to reorganise their networks toward more efficient H&S networks. In consequence, a simple comparison between U.S. airlines and the OS hubbing index, although tempting, would not be appropriate, both because the period of analysis is not the same and because I do not measure the entire network. However, with the previous caveats in mind, the U.S. figures provide an order of magnitude which helps to appreciate OS's extent of hubbing.
2. The three percent criterion accounts for two airports, Vienna and Zurich. However, Vienna contributes to 93 % of the value of the index.

In conclusion, this section highlights the nature of OS's network. Its network, identified as a H&S network, is centred in Vienna. Figure 1.1 in the Appendix (see page 47) illustrates OS's European network. From Figure 1.1 the analogy to a wheel is straightforward.

## 1.4.2 Austrian Domestic Market

OS provides 188 weekly departures and 9'510 seats in its domestic network. This network is composed of 4 main routes: Vienna-Graz, Vienna-Klagenfurt, Vienna-Linz and Vienna-Salzburg. Moreover, connecting flights are provided on the Linz-Salzburg route.

Scheduled domestic flights are also offered by another Austrian certificated airline: Tyrolean Airways. This independent regional carrier operates most of its routes from Innsbruck<sup>29</sup>. Table 1.6 summarises the structure of the Austrian market.

Table 1.6: Austrian Domestic Market

	WEEKLY DEPARTURES		WEEKLY CAPACITY	
AUSTRIAN AIRLINES	188	56.3 %	9'510	57.6 %
TYROLEAN AIRWAYS	146	43.7 %	7'008	42.4 %
	334	100 %	16'518	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and OS official timetable.

At the first glance, Table 1.6 indicates that the domestic market is shared almost equally between OS and Tyrolean Airlines. The aggregate figures provided by the table, however, mask considerable discrepancies related to the diversity of networks. As previously noticed, OS almost provides all traffic from Vienna to four important cities (Graz, Linz, Salzburg and Klagenfurt). Matters are quite different for Tyrolean Airways. In fact, almost half of Tyrolean Airways traffic takes place on the Vienna-Innsbruck route (78 departures). The other routes connect Innsbruck to Graz, Linz and Salzburg. Table 1.7 provides the population distribution of the main Austrian urban agglomerations.

Table 1.7: Austrian Population

VIENNA	GRAZ	LINZ	SALZBURG	INNSBRUCK	KLAGENFURT
1'500'000	243'000	200'000	139'000	117'000	88'000

*Source:* The Statesman's Year Book, 130th edition, 1993-94.

It follows that Vienna is about 12 times bigger than Innsbruck. Consequently, traffic flows are more likely to be larger from/to Vienna, than from/to Innsbruck.

<sup>29</sup>Notice that most regional airlines operate turbo propeller aircraft. Even with a pressurised cabin, it is admitted that propeller aircraft offers a lower quality service in terms of speed and physical comfort with respect to pure jet aircraft. In fact, a passenger's in-flight experience is clearly affected by noise, vibration and pressurisation to a far greater extent in propellers aircraft. As Hanlon [1992] notices, 'perhaps even more important is passengers' perception of propeller aircraft as being "old" and relatively less safe. For all these reasons, passengers tend to prefer jets'.

Putting it another way, except for the Vienna-Innsbruck route, Tyrolean Airways' remaining domestic network is quite negligible. This observation is the *second* important characteristic of OS's network. The main conclusions, here, are the following:

- The Austrian domestic market is shared between *two* airlines.
- OS has four monopoly routes, which correspond to the main cities connecting Vienna. Whereas OS's competitor, Tyrolean Airways, has one monopoly route connecting Vienna and some other less busy routes.
- No foreign airline operates Austrian domestic routes, i.e., cabotage competition is, at the moment, ineffective in Austria.

### 1.4.3 OS's Intra-European Market

Besides OS, other Austrian certificated airlines provide scheduled intra-European services. These are Tyrolean Airways, Lauda Air and Rheintalflug. Lauda Air is, in fact, specialised in long-haul charter services but provides some intra-European flights on the Vienna-London(Gatwick) and Vienna-Munich routes<sup>30</sup>. Rheintalflug is a local airline serving only the small Vienna-Altenrhein route<sup>31</sup>. The total figures of Table 1.4 correspond to the weekly departures and capacity offered by OS in intra-European routes, 485 and 49'878, respectively. Table 1.8 summarises the market share after taking OS's competitors into account. Table 1.8 suggests some

Table 1.8: Intra-European Market

	WEEKLY DEPARTURES		WEEKLY CAPACITY	
AUSTRIAN AIRLINES	485	78.9 %	49'878	85.8 %
TYROLEAN AIRWAYS	100	16.3 %	4'824	8.3 %
LAUDA AIR	18	2.9 %	2'825	4.9 %
RHEINTALFLUG	12	1.9 %	576	1.0 %
	615	100 %	58'103	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and OS official timetable.

important points. First, OS's share is very important. In effect, almost 80 % of any intra-European departure is provided by OS. This feature reflects the previous single designation rule that has given one airline—the flag-carrier—the opportunity to set up a large-scale network of international air services. Second, the share of Tyrolean Airways is quite large in terms of departures but less significant in terms of total capacity provided (8.3%). This arises because smaller aircraft are used by this airline, given that most of its routes connect Innsbruck to near European

<sup>30</sup> Actually, about 80 % of its traffic is in the charter business. Recently, Lufthansa has taken a 27 % stake in Lauda Air.

<sup>31</sup> Altenrhein is a small town on the Swiss border.

cities<sup>32</sup>. Third, Lauda Air's small share is due to its specialisation in long-haul charter services. Finally, Rheintalflug's figures are insignificant with respect to the overall market.

At this point, it would be interesting to see how many European competitors are providing air services in OS's intra-European routes. The ancient regulatory regime with its single designation rule and limited fifth competition rights produced, de facto, duopolies on intra-European routes. Therefore, I want to analyse to what extent the new regulatory environment changed the pattern of the market structure. To this end, I use the ABC World Airways Guide which reports all existing scheduled flights between any city-pairs. Table 1.9 (see page 22) shows all city-pairs served by OS in function of the numbers of firms. From Table 1.9, it appears that 53 European city-pairs are served by OS, 5 of which are domestic ones (in bold). As previously mentioned, OS has the monopoly of these domestic routes. Among the purely intra-European city-pairs, 41 are served by at most two airlines, i.e., OS and, generally, the flag-carrier of the country concerned<sup>33</sup>. Put differently, more than 85 % of OS intra-European city-pairs face at most another competitor. This observation is the *third* important network characteristic: The duopolistic structure of OS's intra-European routes. This feature can be explained by the persistence of some regulatory rigidities and/or by a natural "duopoly" argument<sup>34</sup>. Moreover, it is interesting to observe that 11 city-pair routes are jointly operated with other airlines. Finally, I would stress the lack of fifth and seventh freedom rights on OS's intra-European network.

The main conclusions of this section are:

- Most intra-European air services are provided by OS. Domestic competitors' share accounts for less than 15 %.
- Most OS intra-European routes are served by at most two airlines.

---

<sup>32</sup>There are also some direct services from Graz and Salzburg. In total (domestic+European) Tyrolean Airways serves 11 cities.

<sup>33</sup>As previously mentioned, Lauda Air serves the Vienna-London(Gatwick) route, whereas OS serves the Vienna-London(LHR) route. Therefore, since the service is differentiated, a flight to Gatwick(LGW) being different from a flight to Heathrow(LHR), I assume that OS and Lauda Air do not compete on the same market.

<sup>34</sup>A large number of European regional routes are monopoly routes, irrespective to the degree of market regulation. This is related to the fact that on smaller routes the average costs per seat kilometre fall sharply with an increasing size of aircraft. If only a minimal frequency is needed, e.g., one daily flight, it leads to a natural monopoly.

Table 1.9: OS European City-pairs

<i>City-pairs served by OS only</i>	<i>City-pairs with two airlines</i>	<i>City-pairs with three or more airlines</i>
<b>Vienna-Graz</b> <b>Vienna-Salzburg</b> <b>Vienna-Linz</b> <b>Vienna-Klagenfurt</b> <b>Linz-Salzburg</b> <b>Graz-Zurich</b> Vienna-Turin Vienna-Vilnius Vienna-Belgrade Graz-Athens Vienna-Zurich* Vienna-Geneva* Linz-Zurich* Salzburg-Zurich* Vienna-Copenhagen* Vienna-Stockholm* Vienna-Paris* Vienna-Nice* Vienna-Venice* Vienna-Timisoara* Vienna-Thessaloniki*	<b>Vienna-Berlin</b> <b>Vienna-Dusseldorf</b> <b>Vienna-Hamburg</b> <b>Vienna-Stuttgart</b> <b>Linz-Frankfurt</b> <b>Vienna-Madrid</b> <b>Vienna-Barcelona</b> <b>Vienna-Rome</b> <b>Vienna-Milan</b> <b>Vienna-Malta</b> <b>Vienna-London(LHR)</b> <b>Vienna-Brussels</b> <b>Vienna-St.Petersburg</b> <b>Vienna-Kiev</b> <b>Vienna-Warsaw</b> <b>Vienna-Minsk</b> <b>Vienna-Prague</b> <b>Vienna-Helsinki</b> <b>Vienna-Larnaca</b> <b>Vienna-Budapest</b> <b>Vienna-Sofia</b> <b>Vienna-Zagreb</b> <b>Vienna-Athens</b> <b>Vienna-Istanbul</b> <b>Vienna-Izmir</b>	<b>Vienna-Munich</b> <b>Vienna-Frankfurt</b> <b>Vienna-Amsterdam</b> <b>Vienna-Moscow</b> <b>Vienna-Bucharest</b> <b>Graz-Frankfurt</b> <b>Salzburg-Frankfurt</b>
21	25	7

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and OS official timetable.

*Notes:* \* City-pairs where only joint operations exist, i.e., where only poolpartners provide services, are considered to be operated by only one airline since there is no competition on such a route. Moreover, non-EU airlines providing occasional intercontinental connecting flights are not taken into account.



## 1.5 Swissair (SR) Network's Characteristics

### 1.5.1 Network Description

Swissair is the Swiss flag-carrier and, as is the case for Austrian Airlines, it has a monopoly licence for general traffic from its country. In Table 1.1, it can be noticed that SR's equity share in Crossair amounts to more than 52%. Crossair provides *scheduled* services in Europe and is one of the most important regional carriers. In fact, SR and Crossair cooperate in order to coordinate networks, capacity, timetable, etc. Hence, from an economic point of view, these airlines are not two independent and competitive entities. Consequently, Crossair's network has to be included into SR's European network if we want analyse SR's actual network properly. Table 1.10 illustrates the total of the European departures and capacity

Table 1.10: SR Total Departures and Capacity According to Origin

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
ZURICH	837	49.4 %	78'996	57.9 %
GENEVA	388	22.9 %	35'758	26.2 %
BASLE	246	14.5 %	13'023	9.5 %
LUGANO	152	9.0 %	6'433	4.7 %
BERNE	59	3.5 %	1'947	1.4 %
SION	12	0.7 %	396	0.3 %
	1'694	100 %	136'553	100 %

Source: Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SR official timetable.

offered by SR, in function of the (Swiss) city of origin. The table highlights the importance of Zurich, and to a lesser extent of Geneva, in SR operations. In fact, Zurich's departures and capacity are about twice as large as those provided in Geneva. It should be noticed also that more than 72% and 84% of the departures and capacity, respectively, are provided from these two cities. Table 1.11 considers only intra-European flights, i.e., it excludes Swiss domestic flights.

Table 1.11: SR Intra-European Departures and Capacity According to Origin

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
ZURICH	652	58.3 %	64'483	65.1 %
GENEVA	253	22.6 %	26'025	26.3 %
BASLE	159	14.2 %	6'495	6.55 %
LUGANO	31	2.8 %	1'311	1.30 %
BERNE	23	2.1 %	759	0.75 %
	1'118	100 %	99'073	100 %

Source: Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SR official timetable.

Not surprisingly, once domestic flights are eliminated from the sample, the relative importance of Zurich (and to a lesser extent that of Geneva) increases both in terms of departures and capacity provided. Table 1.11 shows that about 65% of the total intra-European capacity is offered from Zurich. Similarly, Table 1.11 shows that intra-European flights are mainly concentrated in Zurich and Geneva, since total departures and capacity offered in these two cities amounts to 80.9% and 91.4%, respectively. These observations describe the *first* network characteristic: SR operates a network centred mainly at Zurich. The other airports play a secondary role. Geneva is halfway between a regional airport "feeding" Zurich (the cases of Basle, Lugano and Berne) and an independent hub<sup>35</sup>. SR's network is mainly centred in Zurich because it is the main Swiss economic centre benefiting, in addition, from the largest population area. Furthermore, the central geographical location of Zurich contributes to make flight operations concentrate there. Table 1.12 provides the population distribution of the main Swiss urban agglomerations.

Table 1.12: Swiss Population

ZURICH	GENEVA	BASLE	BERNE	LUGANO
840'000	385'000	363'000	300'000	30'000

*Source:* The Statesman's Year Book, 130th edition, 1993-94.

From Table 1.12 it can be observed that Geneva, Basle and to a certain extent Berne, have similar demographic characteristics. However, the development of Geneva as the second international airport is mainly due to its geographic location since Basle and Berne are located near to Zurich<sup>36</sup> (120 kms). In order to assess to what extent SR operates an H&S network, I suggest computing the hubbing index proposed by McShan & Windle [1989]. As before, I compute the total number of weekly departures carried out over the European network. SR serves 72 cities throughout its European network. The total number of departures over its network are 2'861, 837 of which take place in Zurich and 388 in Geneva. Table 1.13 (see page 25) documents the departures and capacity in the main cities of the network. Table 1.13 confirms the importance of Zurich and Geneva in SR's network. The figures of capacity in Table 1.13 stress the relative importance of foreign airports like London(LHR) or Paris<sup>37</sup>.

<sup>35</sup>It is clear that, if I had considered SR's worldwide network, the importance of Zurich would have been enhanced, since most intercontinental flights originate there.

<sup>36</sup>It should be noticed that, in the early 80s, the development of Crossair as a regional carrier contributed to the expansion of Basle and Lugano airports.

<sup>37</sup>London(LHR), for example, offers fewer departures than Basle or Lugano, but since larger aircraft are used on the London route (principally Airbus A310), total capacity provided from London(LHR) is more important.

Table 1.13: Main Cities of SR's European Network

FROM	WEEKLY DEPARTURES	FROM	WEEKLY CAPACITY
ZURICH	837	ZURICH	78'996
GENEVA	388	GENEVA	35'758
BASLE	246	LONDON(LHR)	13'846
LUGANO	152	BASLE	13'023
PARIS	94	PARIS	9'132
LONDON(LHR)	77	LUGANO	6'433

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SR official timetable.

Following McShan & Windle [1989], the three percent criterion of the most utilised airports is 2.16 (3% of 72). This implies the SR's hubbing index,  $I_h^{sr}$ , to be equal to

$$I_h^{sr} = \frac{837 + 388 + (0.16)(246)}{2'861} = 0.44193. \quad (1.2)$$

This result suggests that the extent of SR's hubbing is quite important. It should be noticed that (1.2) is similar to OS's figure in (1.1). This is not surprising since it mainly reflects two (common) features: The exiguity of the domestic market, contributing to concentrate flights in only a few airports and the regulatory environment which limited intra-European expansion. Notice that both Zurich and Geneva contribute to 97% of the value of the index (66% for Zurich only). This result supports the idea that our partial index corresponds closely with the results of identifying European flag-carriers' hubs intuitively (see footnote (27)).

In conclusion, two important features of SR's network are highlighted. First, although Geneva does not have a negligible share of traffic, Zurich is the main airport for SR's operations. Second, SR's network has the characteristics of an H&S network centred mainly in Zurich. Figure 1.2 in the Appendix (see page 48) illustrates SR's European network. Figure 1.2 clearly highlights the dual structure of SR's European network with Zurich and, to a lesser extent, Geneva as hub airports.

## 1.5.2 Swiss Domestic Market

SR and Crossair are the only Swiss certificated airlines providing domestic scheduled services. However, in contrast to Austria, the Swiss domestic market is "open" to foreign airlines (*cabotage*) on the condition that this leg is combined with a route to the foreign country. Foreign airlines only have access to the Geneva-Zurich route. According to the ABC World Airways Guide, a total of 25 weekly departures, corresponding to a capacity of 3'308 seats, are provided by foreign airlines<sup>38</sup>. Actually, it should be stressed that these (exceptional) cases of cabotage are regulated by bilateral agreements between the Swiss authorities and

<sup>38</sup>These airlines are Finnair, Air Portugal, Polish Airlines and Air Algérie.

each specific country. Since international regulatory agreements typically limit cabotage to a maximum of 50% of the capacity of the aircraft, the capacity of 3'308 seats offered on the Geneva-Zurich route are not the actual capacity provided in the domestic leg. It is merely a rough (upwards) approximation which enables a comparison with SR's share of the Swiss domestic market. Table 1.14 illustrates the structure of the Swiss market. Table 1.14 indicates that, when

**Table 1.14: Swiss Domestic Market**

	WEEKLY DEPARTURES		WEEKLY CAPACITY	
SWISSAIR	576	95.85 %	37'553	91.9 %
FOREIGN AIRLINES	25	4.15 %	3'308	8.10 %
	601	100 %	40'861	100 %

Source: Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SR official timetable.

Crossair's network is taken correctly into account, SR has almost the monopoly of the domestic market. Its "hinterland" is certainly not challenged by occasional cabotage rights offered to foreign airlines. This observation highlights the *second* important characteristic of SR's network.

### 1.5.3 The intra-European Market

The Swiss certificated airlines providing intra-European scheduled air services are Air Engadina and, obviously, SR (including Crossair). Air Engadina is an independent regional carrier which operates aircraft on three intra-European routes<sup>39</sup>. This airline provides 32 weekly departures and, given the characteristics of Air Engadina's fleet, it corresponds to a capacity of 640 seats. Table 1.11 has already illustrated SR intra-European departures and capacity. Table 1.15 summarises intra-European market shares and highlights SR's striking share in comparison to Air Engadina.

**Table 1.15: Intra-European Market**

	WEEKLY DEPARTURES		WEEKLY CAPACITY	
SWISSAIR	1'118	97.2 %	99'073	99.3 %
AIR ENGADINA	32	2.80 %	640	0.70 %
	1'150	100 %	99'713	100 %

Source: Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SR official timetable.

Table 1.15 certainly reflects the previous single designation rule that has enabled SR, as the flag-carrier, to set up a large-scale European network. Notice that Table 1.15 does not suggest that only SR provides intra-European services

<sup>39</sup> Actually, Air Engadina operates jet aircraft on the Zurich-Eindhoven, Zurich-Erfurt and Berne-Munich routes.

since, because of bilateral agreements, obviously other **foreign** airlines provide air transportation services between Switzerland and their home countries.

Finally, I investigate the number of competitors SR effectively faces on its network. This should provide insights into what extent the new regulatory regime promotes entry on intra-European routes. In other words, my aim is to show to what extent a given city-pair operated by SR departs from the (traditional) monopoly or duopoly case. Table 1.16 (see page 28) illustrates all city-pairs served by SR in function of the numbers of airlines. According to Table 1.16, SR serves 112 different city-pairs, split into 9 domestic (in bold) and 103 intra-European routes. Table 1.16 shows that among the intra-European city-pairs, 99 are served by **at most two** airlines. This result suggests that more than 96% of SR's intra-European routes face at most one competitor (generally the flag-carrier of the country concerned). Notice also that among the domestic city-pairs, 8 are purely monopoly routes, whereas the Geneva-Zurich route is served by more than three airlines<sup>40</sup>. These overall observations are the *third* characteristic of SR's network. Furthermore, it should be noticed that the Copenhagen-Stockholm route is, in fact, the only example of fifth freedom right granted to SR on its European network.

This section characterises the main features of SR's European network. The principal conclusions are:

- SR operates a network centred mainly in Zurich.
- SR almost has a monopoly of the domestic Swiss market.
- SR, as the Swiss flag-carrier, provides almost all intra-European air services. Domestic competitor's (Air Engadina) share is insignificant.
- Most intra-European city-pairs served by SR are either monopoly or duopoly routes.

..

---

<sup>40</sup>With capacity constraints mentioned previously.

Table 1.16: SR European City-pairs

<i>City-pairs served by SR only</i>	<i>City-pairs with two airlines</i>	<i>City-pairs with three or more airlines</i>
Zurich-Basle	Zurich-Athens	Zurich-Geneva
Zurich-Lugano	Zurich-Larnaca	Copenhagen-Stockholm
Zurich-Sion	Zurich-Istanbul	Zurich-Rome
Geneva-Basle	Zurich-Helsinki	Zurich-Paris
Geneva-Lugano	Zurich-Sofia	Geneva-Paris
Basle-Berne	Zurich-Prague	
Basle-Lugano	Zurich-Warsaw	
Lugano-Berne	Zurich-Zagreb	
Zurich-Thessaloniki*	Zurich-Tirana	
Zurich-Copenhagen**	Zurich-Bucharest	
Zurich-Stockholm*	Zurich-Budapest	
Zurich-Gothenburg*	Zurich-Moscow	
Zurich-Vienna*	Zurich-Hamburg	
Zurich-Ankara	Zurich-Dusseldorf	
Zurich-Belgrade	Zurich-Frankfurt*	
Zurich-Kiev	Zurich-Berlin(Tegel)	
Zurich-Minsk	Zurich-Milan(LIN)	
Zurich-St.Petersburg	Zurich-Malta	
Zurich-Munich	Zurich-Madrid	
Zurich-Palma	Zurich-Barcelona	
Zurich-Valencia	Zurich-Malaga	
Zurich-Klagenfurt	Zurich-Lisbon	
Zurich-Stuttgart	Zurich-Nice	
Zurich-Turin	Zurich-Amsterdam*	
Zurich-Genoa	Zurich-London(LHR)*	
Zurich-Strasbourg	Zurich-Manchester	
Zurich-Marseille	Zurich-Birmingham	
Zurich-Luxembourg	Zurich-Brussels	
Zurich-Dresden	Zurich-Ljubljana	
Zurich-Leipzig	Zurich-Hanover	
Zurich-Jersey	Zurich-Lyon	
Zurich-London(LCY)	Zurich-Nuremberg	
Geneva-Copenhagen*	Geneva-Athens	
Geneva-Budapest	Geneva-Moscow	
Geneva-Valencia	Geneva-Dusseldorf	
Geneva-Malaga	Geneva-Rome*	
Geneva-Berlin(Tempelhof)	Geneva-Madrid	
Geneva-Genoa	Geneva-Barcelona	
Geneva-Bilbao	Geneva-Porto	
Basle-Vienna*	Geneva-Lisbon	
Basle-Leipzig	Geneva-Nice	
Basle-Frankfurt	Geneva-Amsterdam	
Basle-Munich	Geneva-London(LHR)	
Basle-Barcelona	Geneva-Brussels	
Basle-Paris	Geneva-Prague	
Lugano-Munich	Geneva-Munich	
Lugano-Rome	Geneva-Bordeaux	
Lugano-Florence	Geneva-Marseille	
Lugano-Nice*	Geneva-Toulouse	
Berne-Paris*	Basle-Hamburg	
Berne-Brussels	Basle-Berlin(Tempelhof)	
	Basle-Dusseldorf	
	Basle-Amsterdam	
	Basle-London(LHR)	
	Basle-Brussels	
	Lugano-Venice	
51	56	5

*Source:* See Table 1.15. *Notes:* \* City-pairs jointly operated (see Table 1.9). \* Occasional intercontinental connecting flights with very low weekly frequency.

## 1.6 KLM (KL) Network's Characteristics

### 1.6.1 Network Description

KL is the Dutch flag-carrier. As reported in Table 1.1, KL's equity shares in KLM Cityhopper and Transavia Airlines are important, 100% and 80% respectively, and therefore must be considered when carrying out KL's European network analysis. KLM Cityhopper is a regional carrier providing *scheduled* air transportation services, essentially on Dutch domestic routes. KLM Cityhopper operates on behalf of KL and is used, basically, to "feed" the main airport located at Amsterdam. Transavia Airlines is KL's *charter* subsidiary, but since it provides some *scheduled* flights on behalf of KL, I propose including Transavia Airlines' scheduled flights into KL's European network. It is important to stress that a misrepresentation of subsidiaries would provide an incomplete picture of KL's effective European network.

Table 1.17 shows the total of the European departures and capacity provided by KL in function of the Dutch city of origin. Flights are operated from four cities: Amsterdam, Eindhoven, Rotterdam and Maastricht. Table 1.17 emphasises the importance of Amsterdam in KL operations. In fact, according to Table 1.17, about 87% and 93% of departures and capacity respectively, are provided from Amsterdam.

Table 1.17: KL Total Departures and Capacity According to Origin

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
AMSTERDAM	1'129	86.9 %	107'113	93.3 %
EINDHOVEN	70	5.4 %	2'854	2.5 %
ROTTERDAM	57	4.4 %	3'546	3.1 %
MAASTRICHT	43	3.3 %	1'259	1.1 %
	1'299	100%	114'772	100%

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and KL official timetable.

The next table, Table 1.18 (see page 30), illustrates only intra-European flights, i.e., it excludes Dutch domestic flights. Not surprisingly, Amsterdam's share of departures and capacity is even more important, indicating that intra-European flights are typically concentrated in Amsterdam<sup>41</sup>. Tables 1.17 and 1.18 clearly highlight the importance of Amsterdam airport for KL's operations in the Netherlands. This observation is the *first* network characteristic: KL's European network is centred in Amsterdam and its network is characterised by an H&S structure.

<sup>41</sup>Most of the intra-European flights from Rotterdam and Eindhoven are directed to high density traffic routes such as London and Paris.

**Table 1.18: KL Intra-European Departures and Capacity According to Origin**

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
AMSTERDAM	1'072	92.0 %	105'290	95.35 %
EINDHOVEN	36	3.1 %	1'613	1.45 %
ROTTERDAM	57	4.9 %	3'546	3.2 %
	1'165	100 %	110'449	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and KL official timetable.

Using the same procedure developed in Section 1.4, I compute KL's hubbing index,  $I_h^{kl}$ , in order to assess to what extent KL's intra-European network is characterised by the H&S structure. This will also provide a comparison with the networks already analysed. KL serves 71 points<sup>42</sup> throughout its European network, four of which are domestic cities (see Table 1.17). Table 1.19 shows the characteristics, in terms of departures and capacity, of the most utilised airports (points).

**Table 1.19: Main Cities of KL's European Network**

FROM	WEEKLY DEPARTURES	FROM	WEEKLY CAPACITY
AMSTERDAM	1'129	AMSTERDAM	107'113
LONDON(LHR)	96	LONDON(LHR)	12'172
PARIS	72	PARIS	7'834
EINDHOVEN	70	LONDON(LGW)	5'166
LONDON(LGW)	59	ZURICH	3'804
ROTTERDAM	57	ROTTERDAM	3'546

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and KL official timetable.

Table 1.19 indicates that London and Paris are KL's second and third more important European markets, respectively. In order to implement  $I_h^{kl}$ , I compute the total number of weekly departures carried out over the 71 points. Total departures amount to 2'521, 1'129 of which take place in Amsterdam. Consequently, following McShan & Windle [1989], the three percent criterion of the most utilised airports is 2.13 (3% of 71) and KL's hubbing index is

$$I_h^{kl} = \frac{1'129 + 96 + (0.13)(72)}{2'521} = 0.48963. \quad (1.3)$$

In comparison with OS and SR, (1.3) is about 10% higher than (1.1) and (1.2) indicating that KL's extent of hubbing is even more important. It should be noticed that Amsterdam contributes to 91.5% of the value of the index and confirms

<sup>42</sup>In fact, there are 69 different cities, but two cities, London and Milan are actually served at two different airports, Heathrow-LHR and Gatwick-LGW and Malpensa-MPX and Linate-LIN, respectively.



that our partial index is close with identifying hubs intuitively. Clearly, the main reasons for this result are a) the geographic characteristics of the Netherlands (small country leading to a concentration of flights on one major hub airport) and b) the regulation of this industry which has restricted its expansion abroad.

In conclusion, the *first* characteristic of KL's network is that it operates a H&S network centred at Amsterdam. Figure 1.3 in the Appendix (see page 49) illustrates KL's European network and clearly displays the analogy to a wheel, where most of the connections are directed to the (central) hub airport in Amsterdam.

## 1.6.2 Dutch Domestic Market

In order to provide some insights into the Dutch domestic market, the population of the main Dutch agglomerations is reported in Table 1.20.

Table 1.20: Dutch Population

AMSTERDAM	ROTTERDAM	THE HAGUE	UTRECHT	EINDHOVEN	ENSCHDEDE	MAASTRICHT
1'080'000	1'060'000	690'000	540'000	390'000	253'000	164'000

*Source:* The Statesman's Year Book, 130th edition, 1993-94.

As noticed before, the exiguity of the country does not allow for a large domestic market of air transportation services, and ground transportation (intermodal competition) is likely to be a good substitute in the Netherlands. It should be mentioned that domestic air transportation services are not operated by foreign airlines. Some domestic routes are, nevertheless, operated by Dutch certificated airlines. In effect, except for KL, scheduled domestic flights are operated by two regional airlines, LMT<sup>43</sup> and BBA<sup>44</sup>. It should be noticed that like KL, LMT and BBA operate similar aircraft on the domestic market (turbo propeller) and therefore the quality of service in terms of speed and physical comfort is comparable. KL provides 134 weekly departures and 4'323 seats in its domestic network. Its network is composed of two main routes: Amsterdam-Eindhoven and Amsterdam-Maastricht<sup>45</sup>. On these routes, the Dutch flag-carrier is a monopolist. Moreover, KL provides connecting flights on the Eindhoven-Maastricht route. KL's competitors provide aircraft on two routes. LMT operates the Amsterdam-Enschede route and BBA provides connecting flights on the Eindhoven-Maastricht route. Table 1.21 (see page 32) summarises the structure of the Dutch domestic market.

<sup>43</sup>Luchvaart Maatschappij Twente.

<sup>44</sup>Base Business Airlines. BBA's domestic flights were, actually, launched in spring 1993.

<sup>45</sup>To be precise, these routes are operated by Air Exel on behalf of KL.

Table 1.21: Dutch Domestic Market

	WEEKLY DEPARTURES		WEEKLY CAPACITY	
KLM	134	57.3 %	4'323	69.5 %
BBA	60	25.6 %	1'140	18.3 %
LMT	40	17.1 %	760	12.2 %
	234	100 %	6'223	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and KL official timetable.

Table 1.21 indicates that KL provides almost 70% of the total capacity. This is not surprising since from the population table (Table 1.20) it can be noticed that KL domestic routes are likely to generate the largest share of traffic. Therefore, although the domestic market is clearly modest, KL presence in this market is significant in comparison to competitors<sup>46</sup>. This feature is the *second* characteristic of KL network.

### 1.6.3 The Intra-European Market

Besides KL, Dutch certificated carriers providing scheduled intra-European air services are BBA, Flexair, Air Exel and Dynamic Air. Actually, it is important to notice that most of these regional carriers could make use of the more liberal bilateral agreements signed in 1984 between the U.K. and the Netherlands. In fact, among a total of 7 intra-European routes operated by these regional carriers, 5 routes connect Dutch and U.K. cities. BBA is the largest regional carrier and operates the Eindhoven-Manchester, Rotterdam-Manchester and Eindhoven-Hambourg routes. Flexair provides air services on two routes: Amsterdam-London(City) and Rotterdam-London(City). Air Exel serves the Maastricht-London(Stansted) route. Finally, the smallest regional airline, Dynamic Air, serves the Eindhoven-Strasbourg route.

Table 1.18 already illustrated KL total intra-European departures and capacity. Table 1.22 (see page 33) incorporates KL and regional carriers' figures in order to illustrate the structure of the intra-European market. Although Dutch regional carriers could benefit from more liberal air agreements with the U.K., Table 1.22 clearly indicates that KL's share of total scheduled intra-European services is close to the monopolist level, both in terms of departures and capacity.

<sup>46</sup>It could be argued that KL's competitors provide, to some extent, complementary rather than substitute services. LMT, for example, provides aircraft on the Amsterdam-Enschede route and in a sense contributes to "feed" KL's major hub airport.

Table 1.22: Intra-European Market

	WEEKLY DEPARTURES		WEEKLY CAPACITY	
KLM	1'165	91.2 %	110'449	98.1 %
BBA	50	3.9 %	830	0.75%
Flexair	42	3.3%	798	0.71%
Air Exel	17	1.35%	476	0.42%
Dynamic Air	3	0.25%	21	0.02%
	1'277	100 %	112'574	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and KL official timetable.

Finally, I investigate the number of competitors KL effectively faces on its European network. Table 1.23 (see page 34) represents KL routes in function of the number of carriers. From Table 1.23 it follows that KL serves 79 European city-pairs, three of which are domestic (in bold). Among the purely intra-European routes more than 86% of the city-pairs (i.e., 66 routes) are served by at most two airlines, generally KL and the flag-carrier of the country concerned<sup>47</sup>. This result is comparable with the OS's figure found in Section 1.4. It is important to stress that, although Dutch authorities have adopted in some cases a more liberal air policy, KL still faces a relatively few competitors on its European network. This is the *third* characteristic of KL's network. Furthermore, from Table 1.23 it can be noticed that three fifth freedom rights and one cabotage route are granted to KL on the European network. Therefore, although KL could fully take advantage of the Third Package (fifth and seventh freedom competition are granted to any EU certificated carrier), the only fifth freedom competition route operated within the EU is, in 1993, the Luxembourg-Strasbourg route<sup>48</sup>. These results suggest that, so far, KL's effective use of fifth and seventh freedom rights are rather limited.

As concluding remarks, this section characterises the main features of KL's European network. These are a) KL network has the characteristic of the H&S network centred in Amsterdam, b) although the Dutch domestic market is small, KL operates two domestic monopoly routes, c) KL's share of intra-European market is prominent with respect to Dutch competitors and, finally, d) a significant number of intra-European city-pairs operated by KL are either monopoly or duopoly routes.

<sup>47</sup>Notice that since autumn '93 the Amsterdam-Copenhagen and Amsterdam-Stockholm routes are also operated by Iberia. Consequently, the number of airlines operating these routes has recently increased. Moreover, as previously mentioned, Flexair serves the Rotterdam-London(City) route, whereas KL serves the Rotterdam-London(LHR) route. Since the service is differentiated, a flight to London-City being different from a flight to London-Heathrow, I assume that KL and Flexair do not compete on the same route. This explains why the Rotterdam-London(LHR) route is in the first column of Table 1.23.

<sup>48</sup>The other fifth freedom competition routes are the Gothenburg-Helsinki and Helsinki-St.Petersburg routes (see Table 1.23).

Table 1.23: KL European City-pairs

<i>City-pairs served by KL only</i>	<i>City-pairs with two airlines</i>	<i>City-pairs with three or more airlines</i>
Amsterdam-Eindhoven	Maastricht-Eindhoven	Amsterdam-London(LHR)
Amsterdam-Maastricht	Amsterdam-Billund	Amsterdam-Manchester
Amsterdam-Malmö	Amsterdam-Nuremberg	Amsterdam-Gothenburg
Amsterdam-Bremen	Amsterdam-Stuttgart	Amsterdam-Hamburg
Amsterdam-Turin	Amsterdam-Basle	Amsterdam-Frankfurt
Amsterdam-Luxemburg	Amsterdam-Athens	Amsterdam-Vienna
Amsterdam-Strasbourg	Amsterdam-Berlin	Amsterdam-Belfast
Rotterdam-Paris	Amsterdam-Oslo	Gothenburg-Helsinki <sup>a</sup>
Eindhoven-Paris	Amsterdam-Copenhagen	Helsinki-St. Petersburg <sup>a</sup>
Amsterdam-Marseille	Amsterdam-Stavanger	Lisbon-Porto <sup>b</sup>
Amsterdam-Toulouse	Amsterdam-Helsinki	
Amsterdam-Lyon	Amsterdam-Stockholm	
Amsterdam-Dusseldorf	Amsterdam-Munich	
Amsterdam-Milan(MPX)	Amsterdam-Warsaw	
Amsterdam-Venice	Amsterdam-Prague	
Amsterdam-Kiev	Amsterdam-Budapest	
Amsterdam-Hanover	Amsterdam-Geneva	
Amsterdam-Antwerp	Amsterdam-Moscow	
Amsterdam-Guernsey	Amsterdam-Zurich <sup>c</sup>	
Amsterdam-Jersey	Amsterdam-Paris <sup>c</sup>	
Amsterdam-Bristol	Amsterdam-Nice	
Amsterdam-Cardiff	Amsterdam-Milan(LIN)	
Amsterdam-Southampton	Amsterdam-Rome <sup>c</sup>	
Eindhoven-London(LHR)	Amsterdam-Barcelona	
Rotterdam-London(LHR)	Amsterdam-Madrid	
Eindhoven-London(LGW)	Amsterdam-Porto	
Amsterdam-Innsbruck <sup>c</sup>	Amsterdam-Lisbon	
Amsterdam-Salzburg <sup>c</sup>	Amsterdam-Faro	
Amsterdam-London(LGW)	Amsterdam-Brussels	
Amsterdam-Tenerife	Amsterdam-Birmingham	
Amsterdam-Gran Canaria	Amsterdam-Cork	
Amsterdam-Heraklion	Rotterdam-London(LGW)	
Amsterdam-Larnaca <sup>c</sup>	Amsterdam-Istanbul	
	Amsterdam-Málaga	
	Amsterdam-Alicante	
	Luxembourg-Strasbourg <sup>a</sup>	
33	36	10

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and KL official timetable.

*Notes:* <sup>a</sup> City-pairs jointly operated (see Table 1.9). <sup>c</sup> Occasional intercontinental connecting flights with very low weekly frequency. <sup>b</sup> Fifth freedom rights. <sup>d</sup> Eighth freedom rights or cabotage.

## 1.7 SAS (SK) Network's Characteristics

### 1.7.1 Network Description

Scandinavian Airlines System (SK) is a multinationally owned airline, founded in 1946 by a trilateral agreement between the governments of Denmark, Sweden and Norway. The agreement guarantees SK exclusive traffic rights on international flights and on a number of domestic routes in the three Scandinavian countries. SK acquired the majority shareholding in Linjeflyg (LF) in June 1992 (see Table 1.1), a Swedish scheduled airline specialised in domestic flights. As a consequence, from the beginning of 1993, Linjeflyg's operations are integrated with SK's Swedish domestic market. Clearly, this merger significantly affects SK's network since now it operates an extensive intra-Scandinavian network<sup>49</sup>. In what follows, in order to be consistent with the previous sections, I consider SK's intra-Scandinavian market as its domestic market<sup>50</sup>. Table 1.24 illustrates the total of the European departures and capacity offered by SK, in function of the main city of origin.

Table 1.24: SK Total Departures and Capacity According to Origin

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
STOCKHOLM (S)	1'290	23.9 %	127'379	24.5 %
COPENHAGEN (DK)	1'129	20.9 %	119'563	23.0 %
OSLO (N)	580	10.7 %	66'303	12.8 %
GOTHENBURG (S)	244	4.5 %	22'729	4.4 %
BERGEN (N)	146	2.7 %	17'223	3.3 %
TROMSO (N)	137	2.5 %	13'535	2.6 %
Other cities	1'880	34.8 %	152'501	29.4 %
	5'406	100%	519'233	100%

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SK official timetable.

Table 1.24 clearly highlights the importance of Stockholm, Copenhagen and, to a lesser extent, of Oslo. This is not surprising since these cities are Scandinavian's main urban and industrial centres (see Table 1.25 on page 36). Notice that more than 55 % and 60 % of the departures and capacity, respectively, are provided from these three cities. Furthermore, Table 1.24 shows that a significant share of departures and capacity is provided from other Scandinavian cities. This is an important feature of SK's network since it operates an extensive— but sparse— intra-Scandinavian network. SK serves 41 Scandinavian cities, 35 of which provide 34.8 % and 29.4 % of the departures and capacity, respectively.

<sup>49</sup>In terms of operations, this is not a minor merger: Measured in number of flights, Linjeflyg is about the same size as KLM.

<sup>50</sup>It seems natural to consider SK's Scandinavian market as its (homogenous) domestic market, even if there are slight differences among the three Scandinavian airline policies.

Table 1.25: Scandinavian Population

DENMARK	COPENHAGEN	AARHUS	ODENSE	AALBORG
5'200'000	1'400'000	268'000	180'000	157'000

NORWAY	OSLO	BERGEN	TRONDHEIM	STAVANGER
4'300'000	460'000	213'000	138'000	98'000

SWEDEN	STOCKHOLM	GOTHENBURG	MALMO	UPPSALA
8'600'000	680'000	432'000	235'000	170'000

Source: The Statesman's Year Book, 130th edition, 1993-94.

Table 1.26 illustrates only intra-European flights, i.e., it excludes Scandinavian domestic flights. Table 1.26 shows that intra-European flights are concentrated in 7 Scandinavian cities.

Table 1.26: SK Intra-European Departures and Capacity according to Origin

FROM	WEEKLY DEPARTURES		WEEKLY CAPACITY	
COPENHAGEN	387	46.3 %	44'145	48.3 %
STOCKHOLM	234	28.0 %	24'552	26.9 %
OSLO	111	13.3 %	12'732	13.9 %
GOTHENBURG	54	6.5 %	5'107	5.6 %
STAVANGER	36	4.3 %	3'168	3.5 %
BERGEN	7	0.8 %	931	1.0 %
AARHUS	7	0.8 %	770	0.8 %
	836	100%	91'405	100%

Source: Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SK official timetable.

Not surprisingly, more than 87 % and 89 % of total intra-European departures and capacity are provided by the three capitals. It is interesting to notice that once domestic flights are eliminated from the sample, Copenhagen emerges as the major centre for SK's European operations. Stockholm's large share in the overall network (Table 1.24) is due to the domestic traffic that is generated by the acquisition of the Swedish Linjeflyg. This result confirms SK's strategy to position Copenhagen as its major *international* hub. SK's extensive domestic network "feeds" Copenhagen for its intra-European operations<sup>51</sup>. It appears, therefore, that SK operates a main H&S network centred in Copenhagen for the international operations and, to a lesser extent, a second H&S network centred in Stockholm for the domestic flights. This result is the *first* network characteristic.

In order to assess the extent of hubbing, let us compute the McShan & Windle's [1989] hubbing index. To this end, I compute SK's total number of weekly

<sup>51</sup>Clearly, if I had considered SK's worldwide network, the importance of Copenhagen would have been enhanced, since most intercontinental flights originate from there.

departures carried out over the European network. SK provides 6'375 weekly departures over its entire European network, 5'406 of which are purely domestic and 969 intra-European. SK serves 88 different points, 41 of which are domestic Scandinavian cities. The most utilised airports are those mentioned in Table 1.24, with Stockholm (1'290), Copenhagen (1'129) and Oslo (580) amounting to almost 50% of total departures<sup>52</sup>. The three percent criterion of the most utilised airports is 2.64 (3% of 88). This implies SK's hubbing index,  $I_h^{sk}$ , to be equal to

$$I_h^{sk} = \frac{1'290 + 1'129 + (0.64)(580)}{6'375} = 0.43767. \quad (1.4)$$

SK's hubbing index is the lowest among the flag-carriers analysed. In comparison with KL,  $I_h^{sk}$  is 12% lower than  $I_h^{kl}$  (1.3). The fact that SK serves an extended Scandinavian market explains SK's relative low hubbing index. SR (see (1.2)) and SK's hubbing index have the same magnitude, suggesting that both networks present similar characteristics in term of hubbing. In fact, both flag-carriers operate a network centred in a main hub and in a second, minor, hub.

### 1.7.2 Scandinavian Domestic Market

An exhaustive analysis of the Scandinavian domestic market is beyond the purpose of this section because, in contrast to the previous cases, the domestic market covers an extended geographical area and each national government has adopted a different policy to regulate its internal market. As a general feature, each government recognises SK as sole carrier on the entire network of international scheduled flights, and on a number of feeder flights connecting important domestic points with international traffic flows. Then, each government has adopted specific regulations to promote air transportation services in thin regional markets. Clearly, these latter markets concern the small Norwegian and Swedish communities. The Danish domestic market is definitely too negligible to deserve a specific analysis. Moreover, SK's equity share in the main Danish carrier, Danair (DX), amounts to 57%, which allows us to treat Danair as a SK's Danish "feeder". Consequently, my aim in this section is to provide a brief analysis of SK's main competitors in Norway and Sweden. The purpose of the analysis is to reveal to what extent SK's Scandinavian domestic market departs from the traditional monopoly market.

Let us first consider the Norwegian domestic market. Besides SK, two Norwegian carriers provide scheduled domestic air services: Braathens SAFE (BU) and Wideroe's Flyveselskap (WF). Braathens SAFE is a non subsidised regional airline operating jet aircraft similar to that operated by SK, while Wideroe's Flyveselskap is a subsidised regional airline operating turbo propeller aircraft. This latter carrier guarantees minimum air services to small, scattered communities. Clearly, Wideroe's Flyveselskap cannot be treated as a SK's competitor, since

<sup>52</sup>Notice that, in contrast to OS and KL, the most important cities are all domestic airports. This is due to the relative importance of the Scandinavian domestic market.

Wideroe's Flyveselskap and SK's market segments (and networks) are definitely distinct. Wideroe's Flyveselskap rather provides "feeder" services for SK and, to a lesser extent, Braathens SAFE. Consequently, the main Norwegian domestic market is shared by SK and Braathens SAFE. As an attempt to prevent traffic diversion from routes converging on SK international flights, the regulator has explicitly drawn a geographical borderline between the two carriers' fields of operation, hence creating two separate markets (with some exceptions, see Ludvigsen [1993]). Braathens SAFE provides air services to the western and southern parts of Norway, while SK enjoys a monopolistic position in the northern and eastern regions. The split of the domestic market in two regional monopolies allows each airline to cross-subsidise between low and high density markets. Therefore, by granting traffic monopoly rights on a geographical basis, each airline operates, *de facto*, a domestic monopoly market. This solution ensures a stable provision of air services without subsidies. What are SK and Braathens SAFE's domestic market shares? Ludvigsen [1993] provides a detailed analysis of the Norwegian domestic market. According to this author, in 1990, SK and Braathens SAFE's domestic traffic shares were 53% and 47%, respectively. A closer look at the data reveals that among the 27 Norwegian main domestic routes, SK (Braathens SAFE) served 15 (20) routes, 7 (12) of which were complete monopoly routes. Not surprisingly, we notice that SK's main level of traffic is generated from Oslo, Bergen and Stavanger, i.e., Norway's main urban and industrial centres.

Sweden is clearly SK's largest domestic market (see Table 1.25). In July 1992, Sweden's domestic traffic was significantly deregulated. The reactions to the domestic deregulation have been mainly characterised by two features. First, SK has strengthened its leadership with the acquisitions of Linjeflyg and Swedair (JG), the major Swedish domestic carriers. Second, a few very small regional scheduled airlines<sup>53</sup> have started to launch new domestic routes. Unfortunately, at the time of writing, we have very few data concerning these new regional carriers. Their principal characteristics are the following<sup>54</sup>:

- Air Nordic Sweden (DJ) operates some regional scheduled passenger services. It was formed on April 1993 and is based in Västerås<sup>55</sup>.
- Avia (JZ) is a regional carrier operating some domestic routes from Norrköping where it is based<sup>56</sup>.
- Golden Air Flyg (DC) operates one route from Stockholm(Bromma) to Trollhättan<sup>57</sup>.

---

<sup>53</sup>The largest carrier has 220 employees, while SK's employees are 21'400.

<sup>54</sup>Source: Flight International, World airline directory, March 1994, and ABC World Airways Guide, various issues Spring 1993.

<sup>55</sup>Its fleet is composed of 5 Fokker 27-100 (turbo prop.) and has 50 employees.

<sup>56</sup>Its fleet is composed of 5 Saab 340 (turbo prop.) and has 100 employees.

<sup>57</sup>Its fleet is composed of one Saab 340 and has 20 employees.



- Gotia Shuttle Express (G4) operates one high density route: The Gothenburg (Saeve)-Stockholm(Bromma)<sup>58</sup>.
- Holmstroem Air (HJ) operates regional schedule passenger services. It serves 8 points within Sweden<sup>59</sup>.
- City Air Scandinavia (6E), was formed in April 1993 after its acquisition of Malmö Aviation Schedule in 1992. It operates scheduled services on two important routes: The Stockholm(Bromma)-Malmö and the Stockholm(Bromma)-Gothenburg(Landvetter) routes<sup>60</sup>.
- Premiair was formed in late 1993 by the merger of Scanair and Conair of Sweden. It has planned to operate domestic and intra-European routes.
- Transwede Airways (TQ) operates some relatively important domestic routes from Stockholm(Arlanda)<sup>61</sup>.
- Skyways of Sweden (JZ) operates some domestic routes from Stockholm's main airport, Arlanda<sup>62</sup>.
- Sweden Airways (BT) operates scheduled services on one important route: The Gothenburg(Saeve)-Stockholm(Arlanda) route<sup>63</sup>.
- West Air Sweden (PT) is a regional airline based in Karlstad from where it serves some domestic routes<sup>64</sup>.

Although most of these new competitors entered the domestic market during 1993, SK's market dominance is unlikely to be challenged thanks to its new acquisitions. This feature is the *second* characteristic of SK network. It is interesting to note that in the high density markets, i.e., the Stockholm-Gothenburg and Stockholm-Malmö routes, the new competitors either operate from the Stockholm secondary airport (Bromma) or from the Gothenburg secondary airport (Saeve) while SK operates the same routes from Arlanda (Stockholm's main hub) and Landvetter (Gothenburg's principal airport).

### 1.7.3 The Intra-European Market

In Norway, other than SK, Braathens SAFE provides scheduled air services on two intra-European routes: The Oslo-London(Gatwick) and the Oslo-Newcastle route, corresponding to 10 weekly departures and 1'280 seats offered.

---

<sup>58</sup>Its fleet is composed of one Saab 340.

<sup>59</sup>Its fleet is composed of 4 Dornier 228 (turbo prop.).

<sup>60</sup>Its fleet is composed of 8 BA 146 (turbo prop.) and has 220 employees.

<sup>61</sup>It uses jet aircraft (DC9).

<sup>62</sup>Its fleet is composed of Saab 340.

<sup>63</sup>It uses turbo prop. aircraft.

<sup>64</sup>It has 15 employees.

In Sweden, besides SK, there are some Swedish certificated airlines which operate intra-European routes. Air Nordic Sweden operates the Västerås-Helsinki route (10 flights, 400 seats). Transwede Airways operates the high density Stockholm (Arlanda)-London(Gatwick) route<sup>65</sup> (17 weekly departures corresponding to 2'210 seats).

Finally, there are some Danish certificated airlines which operate intra-European routes. Cimber Air Denmark (QI) is based in Sonderborg from where it operates a weekly flight on the Sonderborg-Montpellier route<sup>66</sup>. Maersk Air (DM) is an independent Danish carrier which, besides some domestic routes jointly operated with Danair (DX), also provides a few intra-European routes from Copenhagen and Billund: The Copenhagen-London(Gatwick) (12 flights, 1'536 seats), the Billund-Amsterdam (6 flights, 288 seats), the Billund-Brussels (11 flights, 528 seats), the Billund-Frankfurt (6 flights, 288 seats) and the Billund-London(Gatwick) routes (12 flights, 1'536 seats). Muk Air (ZR) is a small regional carrier providing 10 weekly flights between Copenhagen and Bremen. Therefore, Danish certificated carriers provide relatively more intra-European flights than Swedish and Norwegian certificated carriers. Clearly, as non-EU members, these latter carriers could not enjoy the same market access opportunities in 1993.

Table 1.26 has already illustrated SK intra-European departures and capacity. Table 1.27 summarises intra-European market shares taking all Scandinavian certificated carriers into account.

Table 1.27: Intra-European Market

	WEEKLY DEPARTURES		WEEKLY CAPACITY	
SAS	836	89.8 %	91'405	91.5 %
Braathens SAFE	10	1.1 %	1'280	1.3%
Air Nordic Sweden	10	1.1%	400	0.4%
Transwede Airways	17	1.8%	2'210	2.21%
Cimber Air Denmark	1	0.1%	48	0.05%
Maersk Air	47	5.0%	4'176	4.18%
Muk Air	10	1.1%	360	0.36%
	931	100 %	99'879	100 %

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SK official timetable.

Table 1.27 clearly highlights SK's striking shares in comparison to the other carriers, for both departures and capacity. On the one hand, this reflects the previous single designation rule that has enabled SK to have exclusive intra-European traffic rights. On the other hand, this result is due to the explicit Scandinavian

<sup>65</sup>City Air Scandinavia planned to operate the Malmö-London(City) and the Malmö-Hambourg routes in 1994.

<sup>66</sup>It plans to operate the Kiel-Frankfurt and Kiel-Paris routes (i.e., seventh freedom rights) and the Kiel-Cologne, Kiel-Berlin and Berlin-Bremen routes (i.e., cabotage freedom) in 1994.

agreements which firmly protect SK's traffic rights on the network of international scheduled flights.

Finally, I investigate the number of competitors SK effectively faces throughout its European network. SK operates 164 different city-pairs, 78 of which are domestic (Scandinavian) routes and 86 purely intra-European routes. Table 1.28 (see page 42) and Table 1.29 (see page 43) illustrate SK's domestic and intra-European city-pairs in function of the number of carriers. From Table 1.28 we notice that among the 78 domestic routes, 75 routes (i.e., 96 %) are served by **at most two airlines**. In fact, most of these routes are purely monopoly routes. This result is not surprising given our remarks in the description of the domestic market (see the previous section). If we consider the intra-European city-pairs, Table 1.29 shows that among the 86 routes, 74 routes (i.e., 86%) are served by **at most two airlines**. Clearly, most of these routes are operated by SK and the flag-carrier of the country concerned. Notice that only 14 % of the intra-European city-pairs face three or more airlines. This latter case occurs in high-density routes or routes operated by SK under fifth or cabotage freedom rights. It is also interesting to remark that intra-European routes between Scandinavia and Switzerland and Scandinavia and Austria are jointly operated<sup>67</sup>. The above results suggest that the *third* characteristic of SK's network is the following: A significant number of domestic and intra-European routes operated by SK are either monopoly or duopoly routes.

In summary, this section describes the main features of SK's European network. These are:

- SK operates a main H&S network centred in Copenhagen for its international operations and, to a lesser extent, a second H&S network centred in Stockholm for its large (domestic) Scandinavian market.
- Although a few regional carriers provide domestic air services, SK's domestic market dominance is undeniable. Most of the domestic competitors provide air services to thin and scattered markets and/or "feed" SK's network.
- SK, as the Scandinavian flag-carrier, provides almost all intra-European air services.
- Most city-pairs served by SK in its European network are either monopoly or duopoly routes.

---

<sup>67</sup>This observation suggests that SK, OS and SR's participation in the "European Quality Alliance" is more than what a simple "quality alliance" would require!

Table 1.28: SK Domestic City-pairs

<i>City-pairs served by SK only</i>	<i>City-pairs with two airlines</i>	<i>City-pairs with three or more airlines</i>
Stockholm-Kiruna Stockholm-Gallivare Stockholm-Skelleftea Kiruna-Umea Stockholm-Ornskoldsvik Stockholm-Sundsvall Stockholm-Ostersund Stockholm-Jonkoping Stockholm-Borlange Stockholm-Karlstad Stockholm-Helsingborg Stockholm-Kristianstad Stockholm-Vaxjo Stockholm-Kalmar Stockholm-Ronneby Copenhagen-Aalborg Copenhagen-Aarhus Copenhagen-Karup Oslo-Evenes Oslo-Bardufoss Oslo-Tromso Oslo-Bodo Alta-Kirkenes Bodo-Bardufoss Copenhagen-Gothenburg Stockholm-Oslo* Copenhagen-Stavanger Copenhagen-Vaxjo Copenhagen-Kalmar Copenhagen-Orebro Copenhagen-Vasteras Copenhagen-Norrkoping Copenhagen-Jonkoping Copenhagen-Trondheim Stockholm-Bergen Copenhagen-Bergen Copenhagen-Kristiansand Oslo-Gothenburg Oslo-Haugesund Bodo-Evenes Tromso-Alta Tromso-Kirkenes Sundsvall-Ornskoldsvik Ornskoldsvik-Umea Bardufoss-Evenes Tromso-Trondheim Trondheim-Bardufoss Kirkenes-Lakselv Lakselv-Alta Trondheim-Evenes Tromso-Lakselv Kristianstad-Vaxjo Tromso-Bardufoss Kalmar-Vaxjo Ostersund-Sundsvall Umea-Ostersund Kalmar-Ronneby Gallivare-Kiruna Lulea-Gallivare Sundsvall-Umea Sundsvall-Lulea	Copenhagen-Oslo Stockholm-Lulea Kiruna-Lulea Stockholm-Umea Stockholm-Visby Oslo-Bergen Bergen-Stavanger Oslo-Stavanger Oslo-Trondheim Bodo-Trondheim Bodo-Tromso Tromso-Longyearbyen Tromso-Evenes Lulea-Umea	Stockholm-Malmö Stockholm-Gothenburg Copenhagen-Stockholm
61	42	3

Table 1.29: SK Intra-European City-pairs

<i>City-pairs served by SK only</i>	<i>City-pairs with two airlines</i>	<i>City-pairs with three or more airlines</i>
Copenhagen-Nice	Copenhagen-Riga	Gothenburg-Amsterdam
Stockholm-Nice	Stockholm-Riga	Gothenburg-Helsinki
Copenhagen-Alicante	Copenhagen-Vilnius	Copenhagen-Luxembourg
Copenhagen-Gdansk	Copenhagen-Tallinn	Copenhagen-Manchester
Copenhagen-Kiev	Stockholm-Tallinn	Manchester-Dublin <sup>a</sup>
Bergen-London(LHR)	Copenhagen-Warsaw	Copenhagen-Amsterdam
Copenhagen-Glasgow	Copenhagen-Istanbul	Stockholm-Amsterdam
Aarhus-London(LHR)	Copenhagen-Prague	Copenhagen-Paris(CDG)
Copenhagen-Zurich*	Copenhagen-Athens	Stockholm-Paris(CDG)
Stockholm-Zurich*	Copenhagen-Budapest	Copenhagen-Hamburg
Oslo-Zurich*	Copenhagen-Reykjavik	Hamburg-Leipzig <sup>b</sup>
Stockholm-Geneva*	Stanvager-Glasgow	Stuttgart-Thessaloniki <sup>a</sup>
Copenhagen-Geneva*	Copenhagen-Dublin	
Oslo-Dusseldorf	Gothenburg-Brussels	
Copenhagen-Stuttgart	Gothenburg-Frankfurt	
Copenhagen-Hanover	Copenhagen-London(LHR)*	
Oslo-Rome	Oslo-London(LHR)	
Copenhagen-Venice	Stanvager-London(LHR)	
Copenhagen-Vienna*	Gothenburg-London(LHR)	
Stockholm-Vienna*	Stockholm-London(LHR)	
Stockholm-Vaasa	Stavanger-Aberdeen	
Oslo-Nice	Oslo-Amsterdam	
Oslo-Manchester	Stavanger-Amsterdam	
	Oslo-Paris(CDG)	
	Gothenburg-Paris(CDG)	
	Copenhagen-Madrid	
	Copenhagen-Barcelona	
	Copenhagen-Malaga	
	Stockholm-Brussels	
	Copenhagen-Brussels	
	Brussels-Lyon <sup>a</sup>	
	Oslo-Brussels	
	Stockholm-Dusseldorf	
	Copenhagen-Dusseldorf	
	Copenhagen-Frankfurt*	
	Stockholm-Frankfurt	
	Oslo-Frankfurt	
	Stockholm-Hamburg	
	Stockholm-Munich	
	Copenhagen-Munich	
	Copenhagen-Berlin(Tempelhof)	
	Copenhagen-Rome	
	Copenhagen-Milan(LIN)	
	Stockholm-Milan(LIN)	
	Stockholm-Helsinki	
	Copenhagen-Helsinki	
	Oslo-Helsinki	
	Stockholm-Tampere	
	Stockholm-Turku	
	Stockholm-Moscow	
	Stockholm-St.Petersburg	
23	51	12

*Source:* Author's calculations from data in the ABC World Airways Guide, various issues Spring 1993 and SK official timetable.

*Notes:* \* City-pairs jointly operated (see Table 1.9). \* Occasional intercontinental connecting flights with very low weekly frequency. <sup>a</sup> Fifth/seventh freedom rights. <sup>b</sup> Eighth freedom rights or cabotage.

## 1.8 Conclusion

This chapter has two distinct parts. The first part provides a brief description of the European airline policy before and after 1988, while the second part highlights the key characteristics of some European flag-carriers, based on observations in 1993. In particular, the chapter first defines which subsidiary should be included when analysing a flag-carrier's network. In a second step, it provides a detailed analysis of the flag-carrier's network: Its structure, the main points served (departures and capacity), the domestic and the intra-European market shares and, finally, the degree of competition throughout its European network. Although each flag-carrier possesses its own characteristics, the chapter reveals some common features which are particularly interesting. In effect, the analysis emphasises the following features: a) Flag-carriers typically operate H&S networks, b) their domestic network is mainly a matter of monopoly, and c) most intra-European city-pairs are still operated by the two flag-carriers designated by the old bilateral agreements.

To what extent do the flag-carriers analysed exhibit similarities with other EU airlines ? I strongly believe that, within the class of medium-sized flag-carriers, the same features are likely to arise for many EU flag-carriers. In fact, one can expect to obtain similar results for many flag-carriers such as Sabena<sup>68</sup>, Spanish Iberia, Alitalia, etc.. If these features are present in most EU flag-carriers (in Spring 1993), then taking them into account would be particularly relevant to the understanding and the modelling of intra-EU airline competition. As argued by Daughety [1985], incorporating network details when examining the effects of regulation change on the airline industry, can only enrich the analysis. Recent research in airline economics is directed along this line (see, e.g., Brueckner & Spiller [1991]).

The analytical models presented in the subsequent two chapters, Chapter 2 and Chapter 3, directly stem from the most appealing features described in this empirical chapter. In particular, I model some aspects of EU airline liberalisation which explicitly take a) the hubbing structure, and b) the fact that most city-pairs are either domestic monopoly or intra-European duopoly markets, into account. Moreover, since European flag-carriers typically operate linked (H&S) networks, the lack of entry observed during the first 18 months following the Third Package, could be explained by some strategic effects which arise from repeated interactions among a few flag-carriers (see Chapter 3).

---

<sup>68</sup>Notice that Sabena, as KL, does not operate a domestic network.

## 1.9 References

- ABBOTT, K. and THOMPSON, D.**, 1991, "Deregulating European Aviation: The Impact of Bilateral Liberalization," *International Journal of Industrial Organization*, vol 9, pp.125-140.
- BAUER, P.W.**, 1987, "Airline Hubs: A Study of Determining Factors and Effect," *Federal Reserve Bank of Cleveland Economic Review*, Quarter 4, pp.13-19.
- BETTS, P.**, 1991, *Financial Times*, 1 December 1991.
- BETTS, P. and GARDNER, D.**, 1992, *Financial Times*, 24 June 1992.
- BORENSTEIN, S.**, 1992, "The Evolution of U.S. Airline Competition," *Journal of Economic Perspectives*, 6, pp.45-74.
- BUTTON, K.J. and SWANN, D.**, 1992, "Transatlantic Lessons in Aviation Deregulation: EEC and U.S. Experiences," *Antitrust Bulletin*, vol 37, pp.207-255.
- BRUECKNER, J.K. and SPILLER, P.T.**, 1991, "Competition and Mergers in Airline Networks," *International Journal of Industrial Organization*, 9, pp.323-342.
- DAUGHETY, A.F.**, 1985, "Transportation Research on Pricing and Regulation: Overview and Suggestions for Future Research," *Transportation Research Part-A*, 19, pp.471-487.
- ENCAOUA, D. and PERROT, A.**, 1991, *Concurrence dans le Transport Aérien*, Commission of the European Communities.
- HANLON, J.P.**, 1992, "Regional Air Service and Airline Competition," *Tourism Management*, vol 13, pp.181-195.
- KANAFANI, A.**, 1981, "Aircraft Technology Evaluation and Network Structure in Short Haul Air Transportation," *Transportation Research*, vol 15, pp.305-314.
- KANAFANI, A. and GHOBRIAL, A.**, 1985, "Airline Hubbing: Some Implications for Airport Economics," *Transportation Research Part-A*, vol 19, pp.15-27.
- KEELER, J.P. and FORMBY, J.P.**, 1994, "Cost Economies and Consolidation in the U.S. Airline Industry," *International Journal of Transport Economics*, vol 21, pp.21-45.
- LEVINE, M.E.**, 1987, "Airline Competition in a Deregulated Market: Theory, Firm Strategy, and Public Policy," *Yale Journal on Regulation*, 4, pp.393-494.

- LUDVIGSEN, J.**, 1993, "Liberalization of Market Entry for Norwegian Regional Airlines," *Transportation Journal*, vol 32, pp.41-55.
- McSHAN, S. and WINDLE, R.**, 1989, "The Implications of Hub-and-spoke Routing for Airline Costs and Competitiveness," *The Logistics and Transportation Review*, vol 25, pp.209- 230.
- OUM, T.H. and TRETHERWAY, M.W.**, 1990, "Airline Hub-and-Spoke Systems," *Transportation Research Forum*, 90, pp.380-393.
- PAVAUX, J.**, 1984, *L'Economie du Transport Aérien: la Concurrence Impraticable*, Economica, Paris.
- SCHERER, F. and ROSS, D.**, 1991, *Industrial Market Structure and Economic Performance*, Third Edition, Boston: Houghton Mifflin.
- SPILLER, P.T.**, 1989, "Pricing of Hub-and-spoke Networks," *Economics Letters*, vol 30, pp.165-169.
- VAN DE VOORDE, E.E.**, 1992, "European Air Transport after 1992: Deregulation or Re-regulation ?," *Antitrust Bulletin*, vol 37, pp.507-528.
- VINTON, P.A.**, 1983, "A Simple Hub-and-spoke Model of Optimal International Air Transportation," *International Journal of Transport Economics*, vol 10, pp.593-611.

## 1.10 Appendix



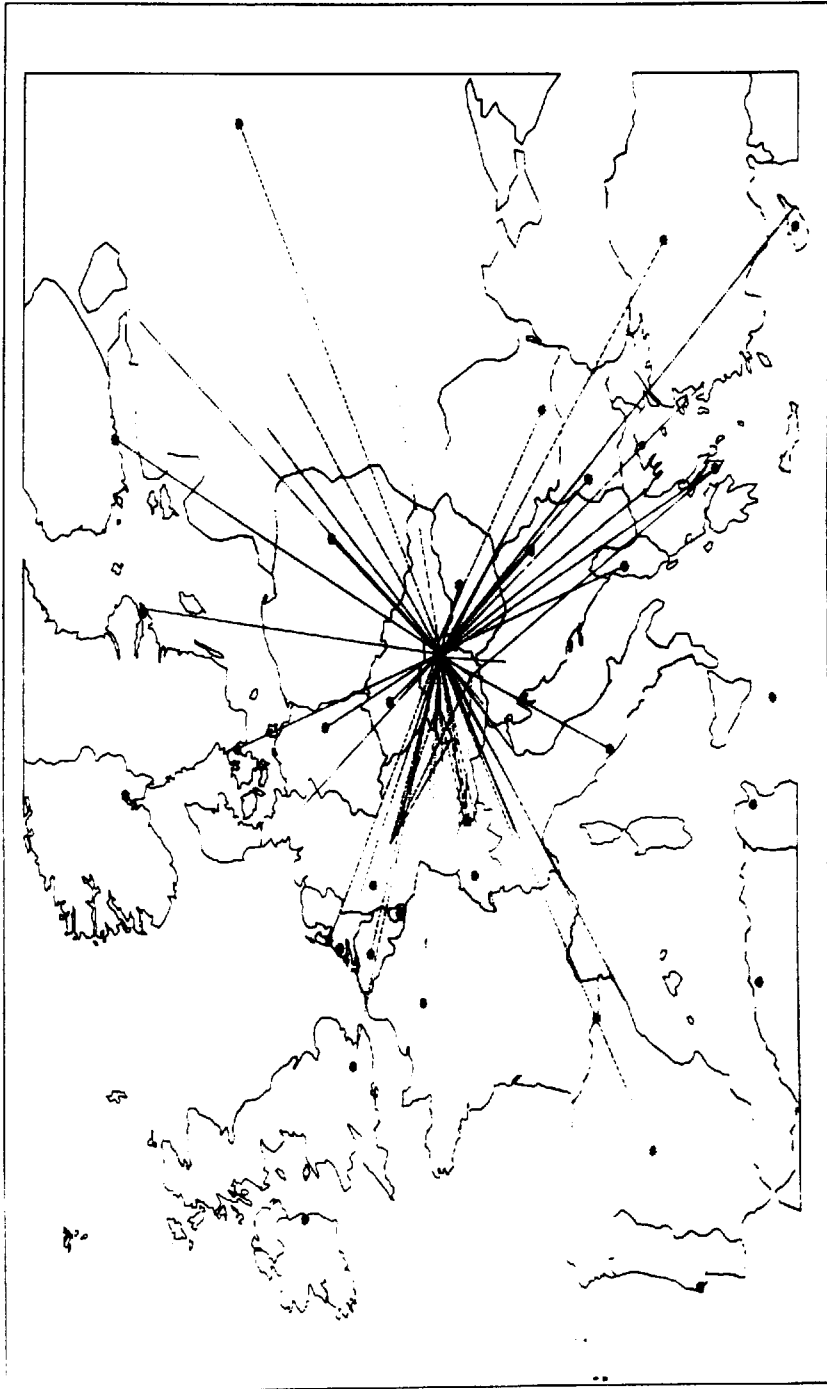


Figure 1.1: OS's European Network in 1993

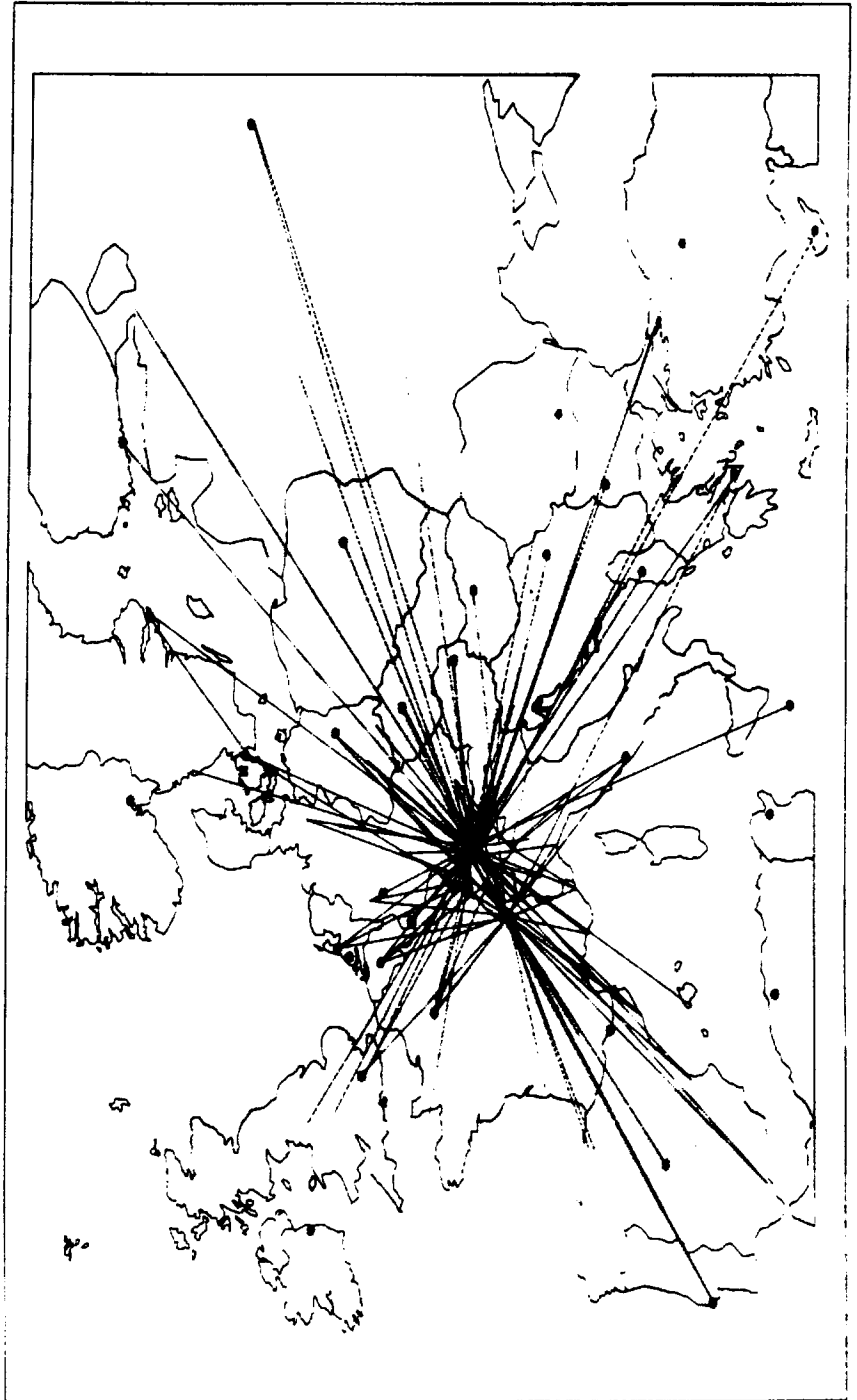


Figure 1.2: SR's European Network in 1993

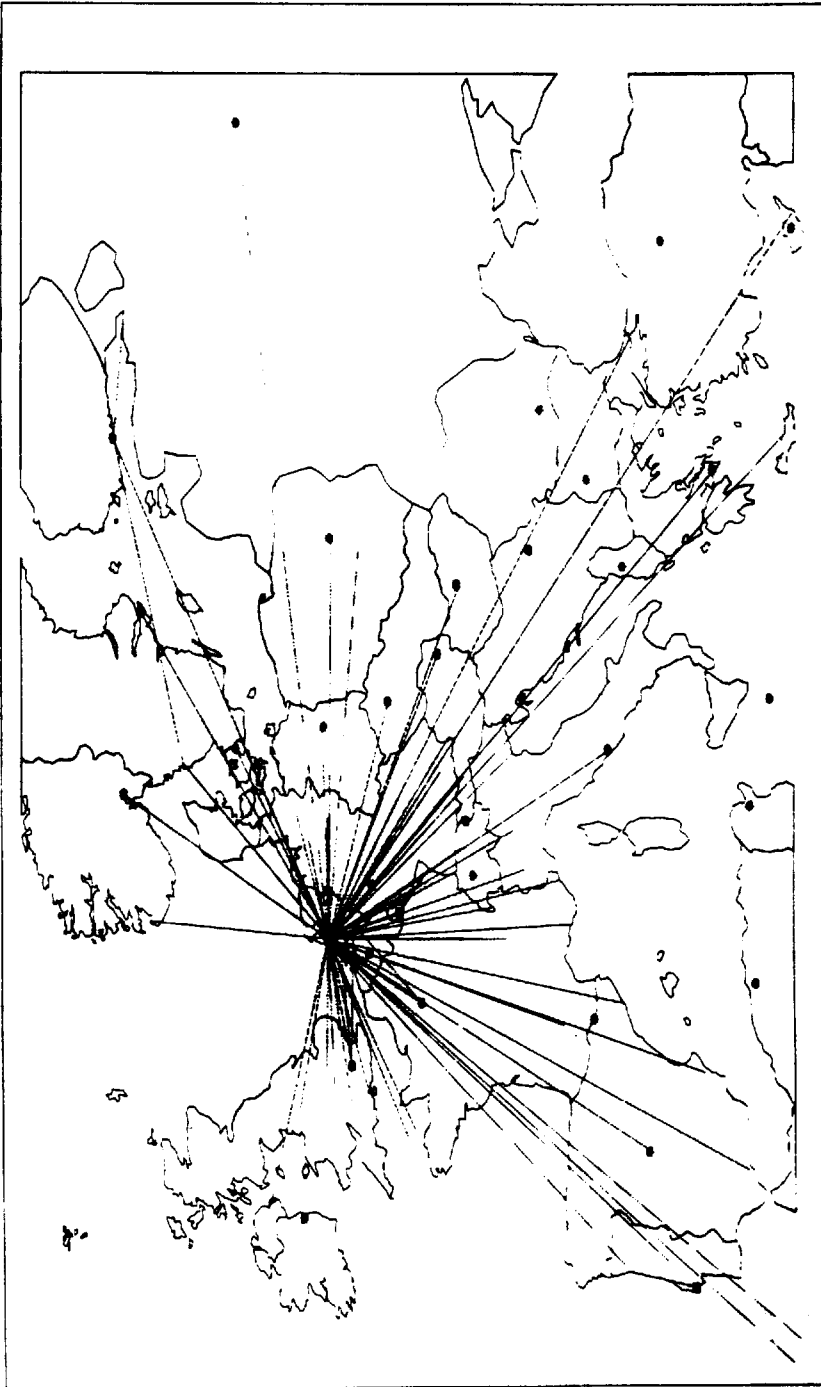


Figure 1.3: KL's European Network in 1993

## Chapter 2

# A Structural Model of Intra-European Airline Competition

### 2.1 Introduction

Given the inherited regulations and the European airline industry specificities highlighted in the precedent chapter, how should the potential benefits stemming from the new regulatory environment be evaluated ? What are the effects of abandoning the (binding) collusive practices in intra-EU airline markets ? Concomitantly, what airline EU merger policy would be more appropriate ? These are the main questions I aim to answer in this chapter. To this end, I suggest the analysis of a structural model of intra-European airline competition<sup>1</sup> that is able to take the main characteristics of this industry into account: **The new EU competition rules and the structure of European airline networks.** The main features of the new EU competition rules concern pricing freedom and market access, which were traditionally regulated through bilateral agreements between governments/countries. The most remarkable feature concerning the structure of European airline networks is that European airlines typically operate hub-and-spoke [hereafter, H&S] networks. In contrast to the U.S., where H&S networks principally emerged as a consequence of the U.S. airline deregulation [1978], in Europe H&S networks have arisen as a consequence of geographic and/or regulatory characteristics<sup>2</sup>.

Various researchers have stressed the importance of networking and multiproduct aspects in airline economics (see Särndal & Statton [1975], Pavaux [1984],

---

<sup>1</sup>Only flag-carriers operating *scheduled* air passengers services are considered. Scheduled services make up slightly more than half the total traffic volume in Europe, as measured in passenger-kilometres. In passenger numbers, the share is much greater, at about 76%, the difference being due to an average scheduled trip length of 700km compared with over 2'000km for *charter*. [AEA Yearbook 1993]

<sup>2</sup>See Chapter 1 for a description of some European h-a-s networks.

Caves et al.[1984], etc.). Recently, Brueckner & Spiller [1991] provided an analytical framework to study the effect of competition in airline H&S networks. My aim is to extend their approach to a two country/two airline model. In fact, while Brueckner & Spiller [1991] analyse the effect of an exogenous change in the number of firms serving a particular market, this chapter is an attempt to analyse the possible effects and the social welfare consequences of the gradual European airline liberalisation. To be more explicit, the model presents various competition scenarios, going from explicit cartel agreements (one characteristic of the pre-liberalisation phase) toward more competitive behaviour. Finally, the model offers some insights into the important merger issue. Nowadays, it seems clear that the future of the European airline industry will depend, to a large extent, on a successful EU merger policy.

The results of the chapter suggest that, when flag-carriers operate H&S networks, the potential welfare gains arising with the abandoning of collusive practices are significant throughout the network. In addition, the model shows that, with increasing returns to density, a cross-border merger between two flag-carriers may increase the net social welfare throughout the network. These results are driven by the network H&S structure and by the returns to density, both of which are key in airline transportation economics.

This chapter is organised as follows. In Section 2.2, I specify the assumptions and set up the model. In Section 2.3 and Section 2.4, I present the collusive agreement and the noncooperative solutions, respectively. Section 2.5 provides a comparison between both solutions. The merger solution is proposed in Section 2.6, and Section 2.7 provides a comparison between the merger and the noncooperative solutions. Section 2.8 concludes.

## 2.2 Assumptions and Model Set-up

The model is based on the following assumptions. The first three are derived from the network characteristics and the regulatory regimes. A tractable model calls for the last assumption.

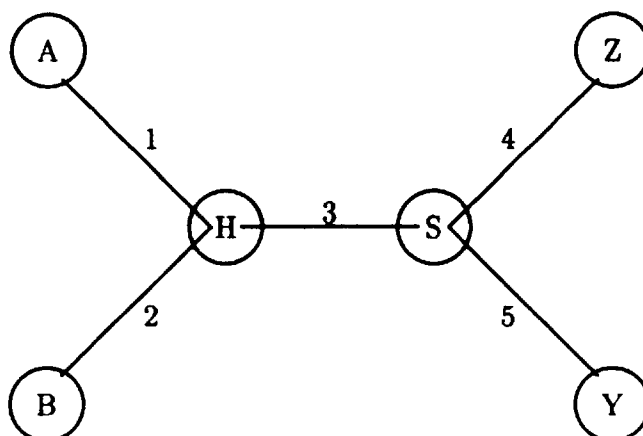
1. The hub-and-spoke [H&S]<sup>3</sup> network is *exogenously* given to both airlines (flag-carriers). In a dynamic perspective, it is clear that the route structure is a key endogenous variable<sup>4</sup>.
2. Each flag-carrier is a monopolist in its "*hinterland*" or *protected market niche*. Consequently, each airline has the monopoly of two purely domestic routes. This assumption reflects the fact that previous bilateral agreements did not make provision for the so-called *cabotage rights*, i.e., the ability to

---

<sup>3</sup>See, e.g., Bauer [1987] for a definition of H&S routing.

<sup>4</sup>However, in the short run, given industry and/or regulatory rigidities observed at the European level, this assumption is not too restrictive.

Figure 2.1: Two Simple Linked H&S Networks



carry passengers within a country by an airline of another country with the origin/destination in its home country<sup>5</sup>. (Complete cabotage freedom in Europe will be granted in April 1997).

3. The two flag-carriers operate one intra-European route, on which they are assumed to provide a *homogeneous* service<sup>6</sup>. On this route, I assume different degrees of *duopolistic*<sup>7</sup> cross-border competition using a quantity setting strategy.
4. For computational convenience, I assume symmetric airlines, i.e., using the same technology<sup>8</sup>, and operating symmetric networks, in particular the legs,  $l = 1, \dots, 5$  of Figure 2.1 all have the same distance. Moreover, airlines face symmetric demand functions.

Figure 2.1 shows two simple linked H&S networks operated by two airlines, Airline 1 in country 1 and Airline 2 in country 2. Cities A, B and H belong to country 1, whereas cities Z, Y and S belong to country 2. Therefore, a total of 6 cities are involved in this structure, implying 15 different city-pair markets<sup>9</sup>. Because of their central locations, cities H and S serve as the hub for Airline 1 and Airline 2 networks, respectively<sup>10</sup>.

<sup>5</sup>In Chapter 1, I find, for example, that in 1993 the domestic market shares (capacity) of Swissair, KLM and Austrian Airlines were, 92%, 70% and 58%, respectively.

<sup>6</sup>European airlines offer very similar ranges of services on intra-European routes.

<sup>7</sup>It should be mentioned that the drawback of this two country/two airline model is that it fails to explicitly take *fifth/seventh freedom* competition into account, i.e., the ability of a third flag-carrier to serve this intra-European route. However, the findings of Chapter 1 tend to support this assumption. In effect, I find that among the 103 intra-European city-pairs operated by Swissair in 1993, 99 are served by at most two airlines, i.e., 96%. Similar figures are found for Austrian Airlines and KLM (85%).

<sup>8</sup>Actually, it should be noticed that most European flag-carriers use similar aircraft on a given route.

<sup>9</sup>With  $n$  the number of cities, the total city-pairs would be  $\frac{n(n-1)}{2}$ .

<sup>10</sup>Cities H and S are, most of the time, the capitals of each country.

In a seminal paper, Caves et al.[1984] have shown that U.S. airlines achieve important **returns to density** within a given network. Returns to density arise when an increase of the volume of transportation services<sup>11</sup> **within a given network** is more important than the associated increase in costs. Their result suggests that an airline marginal cost falls by about 2% for every 10% increase in traffic density<sup>12</sup>. It should be noticed that, in the airline literature, returns to scale are defined as the variation in unit costs with respect to proportional changes in both network size (for example by increasing the cities served) and the provision of transportation services, holding density constant. Similarly, the economies of scope measure the cost advantage of jointly providing a large number of diversified products (city-pairs) as against specialising in the production of a single product (subadditivity criterion). Since the different scenarios analysed in this chapter may affect the density achieved within a given network, only returns to density are considered hereafter<sup>13</sup>.

Moreover, recent theoretical papers have shown that H&S networks are optimal transportation routing<sup>14</sup>. In particular, Hendricks et al.[1995] show that if there are economies of density, the optimal network has the H&S characteristic. In fact, by consolidating the connecting passengers with the same origin but different destinations (or vice versa) on the same route (spoke), the airline gains, principally, two kinds of advantages<sup>15</sup>:

- It increases the density of traffic along each spoke. Therefore, it can use aircraft more intensively by increasing the load factor (rate of capacity utilisation) and/or using larger, more efficient airplanes. In both cases, the unit cost per passenger transported declines<sup>16</sup>.
- The potential increase in frequency<sup>17</sup> (for example, two flights per day instead of one) along each spoke may increase demand and therefore density. However, to the extent that this indirect cost advantage is less important, I avoid dealing with it in the present work.

In summary, in the absence of returns to density, airlines would provide non-stop connections between each pair of cities, for example between *A* and *S*. In the presence of such returns, airlines have an incentive to funnel passengers through

---

<sup>11</sup>Passengers and/or freight.

<sup>12</sup>Recently, Brueckner & Spiller [1994] suggest that returns to density are even stronger than those estimated by Caves et al.[1984].

<sup>13</sup>For a recent survey on the "economies of scale" in the airline industry, see Antoniou [1991]. Levine [1987] provides a general discussion of indivisibilities arising in this industry.

<sup>14</sup>See, e.g., Starr & Stinchcombe [1992].

<sup>15</sup>Besides the opportunity of exerting market power in the hub airport, see Borenstein [1989,1991,1992].

<sup>16</sup>Oum & Tretheway [1990] and recently Starr & Stinchcombe [1992] suggest that the addition of a new city in this system can stimulate traffic density on the other links of the hub, generating further economies.

<sup>17</sup>An important dimension of the quality of service provided.

the hub airport ( $H$  in the previous example). In other words, it is profit maximising to operate one stop services between  $A$  and  $S$ .

In this chapter, I assume that, because of the presence of returns to density, Airline 1 operates aircraft on three legs: Leg 1, 2 and 3. A similar structure is assumed for Airline 2, which operates aircraft on leg 3, 4 and 5. Leg 3 represents the intra-European leg. It connects the two hub airports,  $H$  and  $S$ . Given bilateral agreements, it follows that this leg is served by both airlines. Airline 1 and Airline 2 operate two domestic legs, leg 1 and 2 and leg 4 and 5, respectively. On these routes, each airline is a monopolist. Therefore, in this model:

- Peripheral cities ( $A$  and  $B$  in country 1 and  $Z$  and  $Y$  in country 2) are connected through the hub airport, i.e., with a one stop service.
- Similarly, country 1(2) peripheral cities are connected to country 2(1) cities with a one stop service at least.

Actually, although the model may seem quite restrictive, there is an empirical evidence that most nonstop intra-European services are provided from hub airports (for example Vienna, Amsterdam, Copenhagen, etc.).

I assume that the demand is symmetric across city-pair markets. Consequently, the inverse demand function for round-trip travel in any given city-pair market  $ij$  is given by  $P(Q_{ij})$ , with  $Q_{ij}$  representing the number of round-trip passengers in the market  $ij$ . Therefore,  $Q_{ij}$  represents the number of passengers travelling from city  $i$  to city  $j$  and back, *plus* the number of passengers travelling from city  $j$  to city  $i$  and back. The demand for international services is limited in the sense that  $Q_{AZ}^D = Q_{AY}^D = Q_{BZ}^D = Q_{BY}^D = 0$ . Put it another way, there is no demand between cross-border peripheral cities. While gaining in simplicity<sup>18</sup>, the model captures the following feature: Most intra-European traffic flows stop at hub airports. This is particularly relevant for central EU countries, where capitals attract most leisure and business travellers. In addition, because the change of carrier implies higher risks of missing a connection<sup>19</sup> (often associated with the change of terminal in hubs airports and/or the lack of flight coordination between carriers) or of losing baggage, a passenger originating its journey in  $A$  and willing to fly to city  $S$ , e.g., is assumed to choose the same carrier, i.e., Airline 1. These travellers' preferences ensure that each airline is able to transport their *connecting* passengers on the  $HS$  leg. Airline 1, for example, carries all the  $Q_{AS}$  and  $Q_{BS}$  passengers. Similarly, Airline 2 carries all the  $Q_{ZH}$  and  $Q_{YH}$  travellers.

The assumption of common distance of the legs of Figure 2.1, implies a common cost function,  $C_l(Q_l)$ , applying to each of the legs,  $l = 1, \dots, 5$ . Therefore, this cost function gives the round-trip cost of carrying  $Q_l$  travellers on one leg.

<sup>18</sup>The model is reduced to 11 different city-pairs.

<sup>19</sup>See Carlton et al.[1980] for example.



From the previous assumptions, it follows that  $Q_l$  represent both local as well as connecting passengers. On leg 1, e.g., aircraft carry both local, i.e.,  $A$  to  $H$  passengers, as well as connecting (i.e., same origin but different destinations) passengers<sup>20</sup>. In this case,  $Q_{l=1}$  corresponds to  $Q_{AH} + Q_{AB} + Q_{AS}$ , i.e., all traffic routing through leg 1. The cost function allows for increasing returns to density stemming from hubbing operations. Put differently, the cost function reflects the cost complementarity arising from producing air transportation services (products) in a H&S network. Consequently,  $C_l(Q_l)$  satisfies the following properties:  $C_l(Q_l) > 0$ ,  $C'_l(Q_l) > 0$  and  $C''_l(Q_l) \leq 0$ .

Following Brueckner & Spiller [1991], I adopt the following inverse demand and cost specifications:

$$P(Q_{ij}) = \alpha - \frac{Q_{ij}}{2} \begin{cases} \text{with } i, j = A, B, H, S, i \neq j & \text{for Airline 1} \\ \text{with } i, j = Y, Z, H, S, i \neq j & \text{for Airline 2,} \end{cases} \quad (2.1)$$

and with  $\alpha > 0$ ;

$$C = \sum_l C_l(Q_l) = \sum_l (Q_l - \frac{\theta(Q_l)^2}{2}) \begin{cases} \text{with } l = 1, 2, 3 & \text{for Airline 1} \\ \text{with } l = 3, 4, 5 & \text{for Airline 2,} \end{cases} \quad (2.2)$$

where  $Q_l$  is the traffic volume of the relevant city-pair markets routing through leg  $l$  and  $\theta \geq 0$ <sup>21</sup>.

Consequently, the intercept of the demand function in (2.1),  $\alpha$ , is identical for all city-pair markets. This is equivalent to assuming that the cities are similar in size. By eliminating differences in size between cities, this assumption allows us to highlight the effects of the network structure and of the returns to density on the equilibria in the different competition scenarios. It should be noticed that the demand for travelling in the  $ij$  market does not depend upon prices in any of the other markets<sup>22</sup>. For simplicity's sake, fixed costs are assumed to be zero under this cost specification. Moreover, (2.2) reflects both ground and flight operating costs of transporting a given amount of passengers on a given leg<sup>23</sup>. The extent of increasing returns to density is measured by  $\theta$  in (2.2). Notice that constant returns to density would imply  $\theta = 0$ . From (2.2), it should be noticed that, as long that  $\theta \neq 0$ , the marginal cost of the leg is inferior to its (declining) average cost<sup>24</sup>.

<sup>20</sup>Of course, traffic also includes passengers returning from  $A$  to different destinations.

<sup>21</sup>But not too large, see below.

<sup>22</sup>The idea is that customers who wish to travel from city  $i$  to  $j$  have no desire to travel anywhere else in the network.

<sup>23</sup>This assumption implies ground and flight costs to be proportional, which is realistic if the fuel price is stable.

<sup>24</sup>Alternatively, it can be verified that the cost elasticity,  $\frac{\partial C_l(Q_l)}{\partial Q_l} \frac{Q_l}{C_l(Q_l)}$ , is less than one.

## 2.3 The Collusive Agreements Solution

In order to analyse the effects of liberalisation, I first develop the cartel solution as a benchmark case. This case corresponds closely to the pre-liberalisation case. Under the assumption of (explicit) collusive agreement, Airline 1 and Airline 2 form a cartel on the  $HS$  market. Therefore, on this city-pair, the cartel provides a quantity so as to maximise joint profit<sup>25</sup>. On the other markets, each airline behaves as a monopolist. Given these assumptions, the Airline 1 profit function,  $\Pi_1$ , is

$$\begin{aligned}\Pi_1 = & P(Q_{AH})Q_{AH} + P(Q_{AB})Q_{AB} + P(Q_{BH})Q_{BH} + P(Q_{AS})Q_{AS} \\ & + P(Q_{BS})Q_{BS} + P(Q_{HS})Q_{HS}^1 - C_1(Q_{AH} + Q_{AB} + Q_{AS}) \\ & - C_2(Q_{BH} + Q_{AB} + Q_{BS}) - C_3(Q_{HS}^1 + Q_{AS} + Q_{BS}),\end{aligned}$$

or expressing it explicitly,

$$\begin{aligned}\Pi_1 = & (\alpha - \frac{Q_{AH}}{2})Q_{AH} + (\alpha - \frac{Q_{AB}}{2})Q_{AB} + (\alpha - \frac{Q_{BH}}{2})Q_{BH} \\ & + (\alpha - \frac{Q_{AS}}{2})Q_{AS} + (\alpha - \frac{Q_{BS}}{2})Q_{BS} + (\alpha - \frac{Q_{HS}^1 + Q_{HS}^2}{2})Q_{HS}^1 \\ & - (Q_{AH} + Q_{AB} + Q_{AS} - \frac{\theta(Q_{AH} + Q_{AB} + Q_{AS})^2}{2}) \\ & - (Q_{BH} + Q_{AB} + Q_{BS} - \frac{\theta(Q_{BH} + Q_{AB} + Q_{BS})^2}{2}) \\ & - (Q_{BS} + Q_{AS} + Q_{HS}^1 - \frac{\theta(Q_{BS} + Q_{AS} + Q_{HS}^1)^2}{2}).\end{aligned}\quad (2.3)$$

From (2.3), we observe that Airline 1 revenues are generated from its 6 markets, whereas its costs correspond to aircraft flown on three legs. Notice that in the  $HS$  market, the demand function is given by  $P(Q_{HS}) = \alpha - \left(\frac{Q_{HS}^1 + Q_{HS}^2}{2}\right)$ , with  $Q_{HS} = Q_{HS}^1 + Q_{HS}^2$ , i.e., the total quantity is the sum of the individual quota offered by Airline 1 and Airline 2, respectively. Similarly, the Airline 2 profit function,  $\Pi_2$ , is

$$\begin{aligned}\Pi_2 = & (\alpha - \frac{Q_{ZS}}{2})Q_{ZS} + (\alpha - \frac{Q_{ZY}}{2})Q_{ZY} + (\alpha - \frac{Q_{YS}}{2})Q_{YS} \\ & + (\alpha - \frac{Q_{ZH}}{2})Q_{ZH} + (\alpha - \frac{Q_{YH}}{2})Q_{YH} + (\alpha - \frac{Q_{HS}^1 + Q_{HS}^2}{2})Q_{HS}^2 \\ & - (Q_{ZS} + Q_{ZY} + Q_{ZH} - \frac{\theta(Q_{ZS} + Q_{ZY} + Q_{ZH})^2}{2}) \\ & - (Q_{YS} + Q_{YZ} + Q_{YH} - \frac{\theta(Q_{YS} + Q_{YZ} + Q_{YH})^2}{2}) \\ & - (Q_{ZH} + Q_{YH} + Q_{HS}^2 - \frac{\theta(Q_{ZH} + Q_{YH} + Q_{HS}^2)^2}{2}).\end{aligned}\quad (2.4)$$

<sup>25</sup>See Doganis [1985] for an example of inter-airline pooling agreements.

Joint profit maximisation boils down to maximising  $\Pi^{car} = \Pi_1 + \Pi_2$ . Assuming interior solutions, the solution of the cartel problem implies that the following 12 first order conditions be satisfied:

$$\frac{\partial \Pi^{car}}{\partial Q_{AH}} = 0 \implies \alpha - Q_{AH} = 1 - \theta(Q_{AH} + Q_{AB} + Q_{AS}) \quad (2.5)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{AB}} = 0 \implies \alpha - Q_{AB} = 2 - 2\theta Q_{AB} - \theta(Q_{AH} + Q_{AS} + Q_{BH} + Q_{BS}) \quad (2.6)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{BH}} = 0 \implies \alpha - Q_{BH} = 1 - \theta(Q_{BH} + Q_{AB} + Q_{BS}) \quad (2.7)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{AS}} = 0 \implies \alpha - Q_{AS} = 2 - 2\theta Q_{AS} - \theta(Q_{AH} + Q_{AB} + Q_{HS}^1 + Q_{BS}) \quad (2.8)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{BS}} = 0 \implies \alpha - Q_{BS} = 2 - 2\theta Q_{BS} - \theta(Q_{BH} + Q_{AB} + Q_{HS}^1 + Q_{AS}) \quad (2.9)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{HS}^1} = 0 \implies \alpha - Q_{HS}^1 - Q_{HS}^2 = 1 - \theta(Q_{HS}^1 + Q_{BS} + Q_{AS}) \quad (2.10)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{ZS}} = 0 \implies \alpha - Q_{ZS} = 1 - \theta(Q_{ZS} + Q_{ZY} + Q_{ZH}) \quad (2.11)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{ZY}} = 0 \implies \alpha - Q_{ZY} = 2 - 2\theta Q_{ZY} - \theta(Q_{ZS} + Q_{ZH} + Q_{YS} + Q_{YH}) \quad (2.12)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{YS}} = 0 \implies \alpha - Q_{YS} = 1 - \theta(Q_{YS} + Q_{YZ} + Q_{YH}) \quad (2.13)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{ZH}} = 0 \implies \alpha - Q_{ZH} = 2 - 2\theta Q_{ZH} - \theta(Q_{ZS} + Q_{ZY} + Q_{HS}^2 + Q_{YH}) \quad (2.14)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{YH}} = 0 \implies \alpha - Q_{YH} = 2 - 2\theta Q_{YH} - \theta(Q_{YS} + Q_{YZ} + Q_{HS}^2 + Q_{ZH}) \quad (2.15)$$

$$\frac{\partial \Pi^{car}}{\partial Q_{HS}^2} = 0 \implies \alpha - Q_{HS}^1 - Q_{HS}^2 = 1 - \theta(Q_{HS}^2 + Q_{ZH} + Q_{YH}). \quad (2.16)$$

The economic interpretation of (2.5)-(2.16) is simple. Optimality requires to equalise the marginal revenue (LHS) in city-pair market  $ij$  with its associated marginal cost (RHS). Solving the system (2.5)-(2.16) yields the optimal quantities. It should be pointed out that, given the symmetry, in equilibrium, it must be the case that  $Q_{HS}^1 = Q_{HS}^2$ , i.e., the traffic on the intra-European market is equally divided among both airlines. The optimal quantities<sup>26</sup> are

$$Q_{HS}^1 = Q_{HS}^2 \equiv Q_0^{car} = \frac{(1 - 2\theta)(\alpha(1 - 2\theta) - 1)}{16\theta^2 - 13\theta + 2} \quad (2.17)$$

<sup>26</sup>For the sake of simplicity these quantities are indexed but they should not be confused with the total volume of the leg.

$$Q_{AH} = Q_{BH} = Q_{ZS} = Q_{YS} \equiv Q_1^{car} = \frac{(2 - 3\theta)(\alpha(1 - 2\theta) - 1)}{16\theta^2 - 13\theta + 2} \quad (2.18)$$

$$Q_{AS} = Q_{BS} = Q_{ZH} = Q_{YH} \equiv Q_2^{car} = \frac{\alpha(2 - 2\theta^2 - 2\theta) + 7\theta - 4}{16\theta^2 - 13\theta + 2} \quad (2.19)$$

$$Q_{AB} = Q_{ZY} \equiv Q_3^{car} = \frac{\alpha(2 - 4\theta^2 - \theta) + 6\theta - 4}{16\theta^2 - 13\theta + 2}. \quad (2.20)$$

Therefore, the symmetric structure reduces the joint profit maximisation problem to a four variables problem. This symmetric structure provides a simple way to check the necessary and sufficient second order conditions. In the Appendix (see Section 2.10.1), it is shown that interior solutions exist for  $\theta \leq \frac{13-\sqrt{41}}{32} \cong 0.2062$  (see (2.68)). Similarly, it can be shown that in equilibrium, in order to have both positive quantities and marginal revenues(costs), the following inequalities hold

$$\frac{4 - 7\theta}{2 - 2\theta - 2\theta^2} < \alpha < \frac{2 - 3\theta}{\theta(6 - 10\theta)}. \quad (2.21)$$

Hereafter, I assume that, in equilibrium, both (2.21) and (2.68) are satisfied. Under these conditions, it can be verified that (2.17)-(2.20) are increasing in  $\alpha$ .

**Proposition 1** *As long as  $\theta \in [0, 0.2062]$  and inequalities (2.21) hold, we have that  $Q_1^{car} \geq 2Q_0^{car}$ . PROOF see Appendix.*

Therefore, Proposition 1 suggests that, for a given nonstop market, i.e., a market implying only one leg, the quantity provided by each airline on its monopoly domestic city-pair market (i.e.,  $Q_1^{car}$ ) is larger than the quantity provided by the cartel, i.e.,  $Q_{HS}^1 + Q_{HS}^2 = 2Q_0^{car}$ , on the intra-European  $HS$  market. This result shows that, for a given nonstop market, output or traffic is more restricted under the collusive arrangement than it is under monopoly. As a consequence, ceteris paribus, the price is higher on the intra-European ( $HS$ ) market.

**Proposition 2** *As long as  $\theta \in [0, 0.2062]$  and inequalities (2.21) hold, we have that  $Q_3^{car} \geq Q_2^{car}$ . PROOF see Appendix.*

Proposition 2 suggests that, for a given one stop market, i.e., a market implying two legs, the quantity provided on markets connecting two domestic peripheral cities (markets  $AB, ZY$ ) is higher than the quantity provided on markets connecting a peripheral city and the foreign hub (markets  $AS, BS, ZH, YH$ ). Therefore, although markets  $AB$  and  $ZY$  are served by monopoly airlines, consumers are better off on these markets in comparison with markets affected by the collusive agreement. This result is due to the presence of increasing returns to density. Since each airline has to share the  $HS$  market, under increasing returns to density, lower traffic per airline on that leg raises the marginal cost on the leg and generates a negative externality on markets using that leg ( $AS, BS, ZH, YH$ ).

This explains why, for a given one stop market, the quantity provided by the monopoly airline ( $Q_3^{car}$ ) is higher than the quantity in a market routing through the collusive leg ( $Q_2^{car}$ ).

**Corollary:** Under the (limit) case of constant returns to density ( $\theta = 0$ ), (2.21) implies that<sup>27</sup>  $2 < \alpha$ , we have that  $2Q_0^{car} = Q_1^{car} = \alpha - 1$ , and  $Q_2^{car} = Q_3^{car} = \alpha - 2$ .

Therefore, total traffic in the  $HS$  market,  $2Q_0^{car}$ , is equal to the traffic of the nonstop domestic markets,  $Q_1^{car}$ . This means that, for a given nonstop market, the cartel and the monopoly outcomes are the same. What is the intuitive explanation of this result ? On its domestic route, when  $\theta > 0$ , the monopolist airline fully recognises it, setting a larger quantity than the quantity provided on the collusive route. Notice also that, as expected, in longer journey markets, i.e., markets using two legs ( $Q_2^{car}$  and  $Q_3^{car}$ ), the traffic is less (higher costs imply, ceteris paribus, higher price and lower demand). Again, the previous argument may explain why the traffic is the same ( $Q_2^{car} = Q_3^{car}$ ), whereas under  $\theta \neq 0$  these quantities are different (see Proposition 2).

Moreover, in equilibrium, the model prevents arbitrage opportunities from arising, which is a useful requirement in a transportation network model. In effect, in order to prevent arbitrage opportunities, fares must be set such that

$$\begin{aligned}
P(Q_{AH}) + P(Q_{HS}) &> P(Q_{AS}) \\
P(Q_{BH}) + P(Q_{HS}) &> P(Q_{BS}) \\
P(Q_{ZS}) + P(Q_{HS}) &> P(Q_{ZH}) \\
P(Q_{YS}) + P(Q_{HS}) &> P(Q_{YH}) \\
P(Q_{AH}) + P(Q_{BH}) &> P(Q_{AB}) \\
P(Q_{ZS}) + P(Q_{YS}) &> P(Q_{ZY}),
\end{aligned} \tag{2.22}$$

i.e., the sum of the individual fare for the two legs of the trip (e.g.,  $AH$  plus  $HS$ ) is larger than the fare for a given city-pair market involving one stop (e.g.,  $AS$ ). If this were not the case, it would be profitable for the traveller to purchase the tickets separately. Given the inverse demand function (2.1) and (2.17)-(2.20), (2.22) is reduced to

$$P(Q_1^{car}) + P(2Q_0^{car}) > P(Q_2^{car}) \quad \text{and} \quad 2P(Q_1^{car}) > P(Q_3^{car}). \tag{2.23}$$

It can be shown that this is verified when the first order conditions (2.5)-(2.16) and the second order conditions (2.68) (see Appendix) are satisfied.

..

---

<sup>27</sup>In fact, the right hand side of (2.21) tends to a vertical asymptote as  $\theta \rightarrow 0$ .

## 2.4 The Noncooperative Solution

The introduction of the Third Package of regulations (January 1993) will not promote airline competition on all EU routes in the same way. On the one hand, access to domestic routes is restricted since cabotage traffic rights will still be severely regulated until 1997. As a consequence, flag-carriers' hinterlands are unlikely to disappear within the Third Package. On the other hand, intra-European routes are the subject of more competitive rules. First, any EU certificated airline can provide capacity between two countries (fifth/seventh freedom competition). Second, the Commission is going to seriously prevent airlines from making binding agreements on capacity and fares. In the short run, while the former decision is likely to only affect the most profitable intra-European routes<sup>28</sup>, the latter decision is likely to affect many intra-European routes<sup>29</sup>. Consequently, this section focuses on this second effect.

I assume that both flag-carriers, Airline 1 and Airline 2, compete in the intra-European market  $HS$ , while continuing to exercise monopoly power in their domestic markets. Therefore, although tacit collusion could not, a priori, be excluded under the new regulatory environment, I assume that both airlines act individually (i.e., noncooperatively) on the  $HS$  market. Airlines are assumed to play a Cournot static ("one shot") game. Two lines of argument are in favour of a quantity setting model. First, Cournot behaviour in the airline industry has found empirical support in the literature (Reiss & Spiller [1989], Brander & Zhang [1990,1993]). Brander & Zhang's [1990] paper is particularly relevant for our analysis since they estimate conjectural variation parameters for *duopoly* airline routes<sup>30</sup>. They find that, in general, the Cournot assumption is consistent with the data<sup>31</sup>. Second, to the extent that the two flag-carriers have been keeping, until recently, stable bilateral agreements, it is unlikely that they would compete more vigorously (e.g., Bertrand behaviour) than Cournot competition would imply. More importantly, perhaps, is the general perception among airline managers that capacity (and therefore frequency) is the key variable in this industry. It is not surprising that American Airlines Chairman, Robert Crandall, recently reported that<sup>32</sup> "capacity is how we compete in this business."

---

<sup>28</sup>Recent developments suggest that European airlines are reluctant to exploit the new entry opportunities. There may be several reasons why European airlines stick to their past networks: Economic downturn, fear of retaliation, high sunk costs associated with entry into a new route, etc.. For more details see Chapter 3.

<sup>29</sup>Therefore, the drawback of this two country/two airline model (it fails to explicitly take fifth/seventh freedom competition into account) is less important.

<sup>30</sup>Their data set consists of 33 duopoly routes served by American Airlines and United Airlines in Chicago in 1985.

<sup>31</sup>Their related paper of 1993 examines the dynamic pattern of firm conduct. Although they are able to reject the hypothesis that the dynamic path of quantities and prices was characterised by mere repetition of the Cournot one shot solution, they suggest that data are more consistent with a quantity setting regime-switching model.

<sup>32</sup>Fortune Magazine, 14 July 1993, p.53.

In order to provide a simple comparison with the cartel solution, I assume the same symmetric networks (Figure 2.1) and same demand assumptions on travellers' preferences for intra-European air services. Consequently, the Airline's 1 problem reduces to maximising

$$\begin{aligned}\Pi_1 = & P(Q_{AH})Q_{AH} + P(Q_{AB})Q_{AB} + P(Q_{BH})Q_{BH} + P(Q_{AS})Q_{AS} \\ & + P(Q_{BS})Q_{BS} + P(Q_{HS})Q_{HS}^1 - C_1(Q_{AH} + Q_{AB} + Q_{AS}) \\ & - C_2(Q_{BH} + Q_{AB} + Q_{BS}) - C_3(Q_{HS}^1 + Q_{AS} + Q_{BS}),\end{aligned}\quad (2.24)$$

where  $\Pi_1$  is its profit function. Similarly, the Airline's 2 problem is to maximise its profit function,  $\Pi_2$ , i.e.,

$$\begin{aligned}\Pi_2 = & P(Q_{ZS})Q_{ZS} + P(Q_{ZY})Q_{ZY} + P(Q_{YS})Q_{YS} + P(Q_{ZH})Q_{ZH} \\ & + P(Q_{YH})Q_{YH} + P(Q_{HS})Q_{HS}^2 - C_4(Q_{ZS} + Q_{ZY} + Q_{ZH}) \\ & - C_5(Q_{YS} + Q_{YZ} + Q_{YH}) - C_3(Q_{HS}^2 + Q_{ZH} + Q_{YH}).\end{aligned}\quad (2.25)$$

We can notice that (2.24) and (2.25) are similar to (2.3) and (2.4). However, now each individual airline has to select a quantity of output to maximise its own profit. The Cournot behavioural assumption implies that when Airline 1(2) maximises its own profit, it takes Airline's 2(1) quantity as given. The symmetry of the model allows the analysis to concentrate on the symmetric Cournot-Nash equilibrium where  $Q_{HS}^1 = Q_{HS}^2$ . For simplicity, I work out the solution in terms of Airline 1. Given (2.1) and (2.2), it follows that the maximisation of (2.24) implies that the following 6 first order conditions be satisfied

$$\frac{\partial \Pi_1}{\partial Q_{AH}} = 0 \implies \alpha - Q_{AH} = 1 - \theta(Q_{AH} + Q_{AB} + Q_{AS}) \quad (2.26)$$

$$\begin{aligned}\frac{\partial \Pi_1}{\partial Q_{AB}} = 0 \implies & \alpha - Q_{AB} = 2 - 2\theta Q_{AB} \\ & - \theta(Q_{AH} + Q_{AS} + Q_{BH} + Q_{BS})\end{aligned}\quad (2.27)$$

$$\frac{\partial \Pi_1}{\partial Q_{BH}} = 0 \implies \alpha - Q_{BH} = 1 - \theta(Q_{BH} + Q_{AB} + Q_{BS}) \quad (2.28)$$

$$\begin{aligned}\frac{\partial \Pi_1}{\partial Q_{AS}} = 0 \implies & \alpha - Q_{AS} = 2 - 2\theta Q_{AS} \\ & - \theta(Q_{AH} + Q_{AB} + Q_{HS}^1 + Q_{BS})\end{aligned}\quad (2.29)$$

$$\begin{aligned}\frac{\partial \Pi_1}{\partial Q_{BS}} = 0 \implies & \alpha - Q_{BS} = 2 - 2\theta Q_{BS} \\ & - \theta(Q_{BH} + Q_{AB} + Q_{HS}^1 + Q_{AS})\end{aligned}\quad (2.30)$$

$$\frac{\partial \Pi_1}{\partial Q_{HS}^1} = 0 \implies \alpha - Q_{HS}^1 - \frac{1}{2}Q_{HS}^2 = 1 - \theta(Q_{HS}^1 + Q_{BS} + Q_{AS}). \quad (2.31)$$

Notice that the marginal revenue in (2.31) is now different from the marginal revenue in (2.10), reflecting the Cournot assumption. Solving the system (2.26)-(2.31) yields the following Cournot-Nash equilibrium quantities

$$Q_{HS}^1 \equiv Q_0^{comp} = \frac{(2 - 4\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3} \quad (2.32)$$

$$Q_{AH} = Q_{BH} \equiv Q_1^{comp} = \frac{(3 - 5\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3} \quad (2.33)$$

$$Q_{AS} = Q_{BS} \equiv Q_2^{comp} = \frac{\alpha(3 - 3\theta - 4\theta^2) + 11\theta - 6}{26\theta^2 - 20\theta + 3} \quad (2.34)$$

$$Q_{AB} \equiv Q_3^{comp} = \frac{\alpha(3 - 2\theta - 6\theta^2) + 10\theta - 6}{26\theta^2 - 20\theta + 3}. \quad (2.35)$$

In equilibrium, it can be shown that  $Q_{HS}^2 = Q_0^{comp}$ ,  $Q_{ZS} = Q_{YS} = Q_1^{comp}$ ,  $Q_{ZH} = Q_{YH} = Q_2^{comp}$ ,  $Q_{ZY} = Q_3^{comp}$ , i.e., Airline's 2 optimal quantities are similar.

As before, this symmetric structure provides a simple way to check the second order conditions. In the Appendix (see Section 2.10.4), it is shown that interior solutions exist for  $\theta < \frac{20 - \sqrt{88}}{52} \cong 0.2042$  (see (2.71)). Furthermore, in equilibrium, in order to have both positive quantities and marginal revenues(costs), the following inequalities must hold

$$\frac{6 - 11\theta}{3 - 3\theta - 4\theta^2} < \alpha < \frac{3 - 5\theta}{\theta(9 - 16\theta)}. \quad (2.36)$$

Hereafter, I assume that, in equilibrium, both (2.36) and (2.71) are satisfied. Under these conditions, one can verify that (2.32)-(2.35) are increasing in  $\alpha$ .

**Proposition 3** *As long as  $\theta \in [0, 0.2042]$  and inequalities (2.36) hold, we have that  $2Q_0^{comp} > Q_1^{comp}$ . PROOF see Appendix.*

Proposition 3 suggests that, for a given nonstop market (i.e., a market implying only one leg), the total quantity provided on the competitive intra-European market ( $2Q_0^{comp}$ ) is larger than the quantity provided on the monopoly domestic market ( $Q_1^{comp}$ ). In other words, this result shows that, for a given nonstop market, output or traffic is more restricted under monopoly than it is under Cournot competition. As a consequence, ceteris paribus, the price is higher on the domestic market. It should be noticed that, as expected, Proposition 3 is the reverse of Proposition 1.

**Proposition 4** *As long as  $\theta \in [0, 0.2042]$  and inequalities (2.36) hold, we have that  $Q_3^{comp} \geq Q_2^{comp}$ . PROOF see Appendix.*

Consequently, although market  $AB$  is served by Airline 1 as a monopolist, Proposition 4 implies that the traffic between these two domestic peripheral cities is higher than the traffic between a peripheral city and the foreign hub (markets  $AS$  and  $BS$ ). This counter intuitive result is due to the presence of increasing returns to density. On the  $HS$  market, Airline 1 has to divide the market with its competitor. In the presence of increasing returns to density, lower traffic on the



$HS$  leg raises the marginal cost on the leg and generates a negative externality on markets using that leg ( $AS$  and  $BS$ ). This explains why, for a given one stop market, the quantity provided by the monopoly airline ( $Q_3^{comp}$ ) is higher than the quantity in a market routing through the competitive segment ( $Q_2^{comp}$ ). Notice that Proposition 4 is similar to Proposition 2.

**Corollary:** Under the (limit) case of constant returns to density ( $\theta = 0$ ), (2.36) implies that  $2 < \alpha$ , we have that  $2Q_0^{comp} = \frac{4(\alpha-1)}{3}$ ,  $Q_1^{comp} = \alpha - 1$ , and  $Q_2^{comp} = Q_3^{comp} = \alpha - 2$ .

It follows that, in equilibrium, total traffic in the  $HS$  market ( $2Q_0^{comp}$ ), is *always* greater than the traffic of the nonstop domestic markets ( $Q_1^{comp}$ ), independent of the degree of returns to density. This result is an important feature of the model and departs from the previous result under the collusive agreement (Section 2.3), where we found that  $2Q_0^{car} = Q_1^{car}$  when  $\theta = 0$ . It can be noticed that, as expected, in longer journey markets, i.e., markets using two legs ( $Q_2^{comp}$  and  $Q_3^{comp}$ ), the optimal quantity is less than in shorter journey markets. Moreover, under constant returns to density, we have that  $Q_2^{comp} = Q_3^{comp}$ . This latter result is similar to the result derived in the collusive solution (Section 2.3).

As previously, it can be shown that, in equilibrium, arbitrage conditions (2.22) hold when (2.36) and (2.71) are satisfied.

## 2.5 The Collusive Versus the Noncooperative Solution

Given the results obtained under the cartel solution (Section 2.3) and the non-cooperative solution (Section 2.4), it is interesting to compare both scenarios, in order to assess which solution is socially preferable. In fact, until now I have compared quantities *within* a given solution. In this section, I provide a comparison of quantities between the two solutions and I measure the change in welfare arising from the more competitive environment. Therefore, these results could provide an assessment of the new regulatory rules introduced in the EU airline industry.

A proper comparison implies the restriction of  $\alpha$  in order to satisfy both solutions. In fact, in order to satisfy (2.21) and (2.36), the following inequalities must hold

$$\frac{4 - 7\theta}{2 - 2\theta^2 - 2\theta} < \alpha < \frac{3 - 5\theta}{\theta(9 - 16\theta)}. \quad (2.37)$$

Hereafter, I assume that both (2.37) and (2.71) are satisfied in equilibrium.

**Proposition 5** *As long as  $\theta \in [0, 0.2042]$  and inequalities (2.37) hold, we have that  $2Q_0^{comp} > 2Q_0^{car}$ ,  $Q_1^{comp} \geq Q_1^{car}$ ,  $Q_2^{comp} \geq Q_2^{car}$  and  $Q_3^{comp} \geq Q_3^{car}$ . Therefore,*

given the specifications of the model, we have that the noncooperative solution provides a strictly greater quantity in the *HS* market and greater or equal quantities in all other markets. *PROOF* see Appendix.

**Corollary:** Under the (limit) case of constant returns to density ( $\theta = 0$ ), (2.37) implies that  $2 < \alpha$ , we have that  $2Q_0^{comp} > 2Q_0^{car}$ ,  $Q_1^{comp} = Q_1^{car}$ ,  $Q_2^{comp} = Q_2^{car}$ , and  $Q_3^{comp} = Q_3^{car}$ .

Proposition 5 is our first important theoretical result. Competition on the intra-European leg not only increases the quantity provided on that market, but also increases the quantity on all other markets as soon as returns to density are increasing. This outcome occurs whenever the demand is weak or strong, so long as  $\alpha$  satisfies (2.37). Therefore, all consumers of the network benefit from a greater competition on the intra-European route. This positive externality arises since the greater quantity on the *HS* market (as a whole) lowers the marginal cost on the leg, which in turn implies a lower price for the markets routing through the competitive segment. It should be stressed that this positive externality occurs also on markets not directly affected by the intra-European route, i.e., the purely domestic markets. This result tends to show that competition on one important market<sup>33</sup> has widespread *positive* effects throughout the network. A misrepresentation of such effects would provide an important bias in the analysis of the EU airline liberalisation. Table 2.1 in the Appendix (see page 81), summarises these results for various values of  $\theta$  up to 0.20.

The next step is to compute the net social welfare (NSW) arising from both solutions. Net social welfare is defined as the sum of consumers' surplus (CS) on each market  $ij$  plus the economic profit of the industry<sup>34</sup>. In the case of the linear inverse demand (2.1), the CS is represented in Figure 3.3 (see page 65). Therefore, in a given market  $ij$ , the CS is equal to

$$CS = \frac{[\alpha - (\alpha - \frac{Q_{ij}^*}{2})]Q_{ij}^*}{2} = \left(\frac{Q_{ij}^*}{2}\right)^2. \quad (2.38)$$

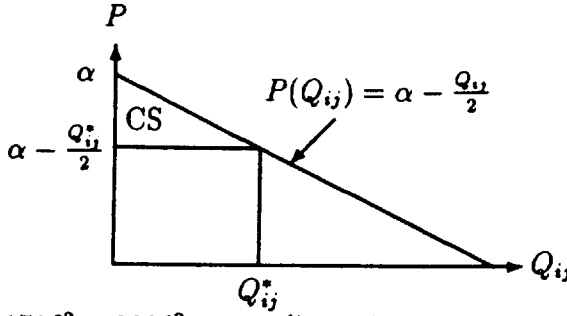
Given (2.38) and (2.17)-(2.20), we can show that the consumer surplus throughout the network under the collusive solution,  $CS^{car}$ , is given by the following expression

$$\begin{aligned} CS^{car}(\theta, \alpha) &= 2\left(\frac{2(Q_0^{car})^2}{4}\right) + 4\left(\frac{Q_1^{car}}{2}\right)^2 + 4\left(\frac{Q_2^{car}}{2}\right)^2 + 2\left(\frac{Q_3^{car}}{2}\right)^2 \\ &= (Q_0^{car})^2 + (Q_1^{car})^2 + (Q_2^{car})^2 + \frac{(Q_3^{car})^2}{2} \end{aligned} \quad (2.39)$$

<sup>33</sup>It is important because it connects two hub airports.

<sup>34</sup>For the sake of comparison with the merger solution (Section 2.6), I consider NSW on the entire network to be composed of country 1 and country 2. Also, I assume that moving from one solution to the other does not induce an income effect.

Figure 2.2: Linear Demand and Consumer Surplus



$$= \frac{\alpha^2(22 - 92\theta + 171\theta^2 - 208\theta^3 + 128\theta^4) - \alpha(68 - 224\theta + 184\theta^2) + 58 - 192\theta + 160\theta^2}{2(16\theta^2 - 13\theta + 2)^2}.$$

Similarly, given (2.38) and (2.32)-(2.35), the consumer surplus throughout the network under the noncooperative solution,  $CS^{comp}$ , is

$$\begin{aligned} CS^{comp}(\theta, \alpha) &= (Q_0^{comp})^2 + (Q_1^{comp})^2 + (Q_2^{comp})^2 + \frac{(Q_3^{comp})^2}{2} \quad (2.40) \\ &= \frac{\alpha^2(53 - 244\theta + 492\theta^2 - 624\theta^3 + 396\theta^4)}{2(26\theta^2 - 20\theta + 3)^2} + \\ &\quad \frac{-\alpha(160 - 576\theta + 536\theta^2 - 32\theta^3) + 134 - 476\theta + 424\theta^2}{2(26\theta^2 - 20\theta + 3)^2}. \end{aligned}$$

Given (2.1), (2.2), (2.66) and the optimal quantities (2.17)-(2.20), the economic profit of the industry under the collusive arrangement is

$$\Pi^{car}(\theta, \alpha) = \frac{\alpha^2(11 - 23\theta + 8\theta^2) - \alpha(34 - 56\theta) + 29 - 48\theta}{16\theta^2 - 13\theta + 2}. \quad (2.41)$$

Similarly, the economic profit of the industry under the noncooperative solution is twice Airline's 1 profit (see (2.69)). Given the optimal quantities (2.32)-(2.35), this expression is equal to

$$\begin{aligned} \Pi^{comp}(\theta, \alpha) &= \frac{\alpha^2(49 - 438\theta + 1196\theta^2 - 1204\theta^3 + 332\theta^4)}{(26\theta^2 - 20\theta + 3)^2} + \\ &\quad \frac{-\alpha(152 - 1292\theta + 3144\theta^2 - 2360\theta^3) + 130 - 1106\theta + 2696\theta^2 - 2028\theta^3}{(26\theta^2 - 20\theta + 3)^2}. \quad (2.42) \end{aligned}$$

Since we have demonstrated that quantities under the noncooperative solution are greater than under the collusive solution, it must be the case that  $CS^{comp} > CS^{car}$ . Of course, the profit of the industry is larger under the collusive agreement. Therefore, the comparison of the NSW reflects these two contrasting effects. Given (2.39), (2.40), (2.41) and (2.42), we can show that  $NSW^{comp} - NSW^{car} > 0$ , for any  $\theta \in [0, 0.2042]$  and  $\alpha$  satisfying (2.37). Figure 2.3 (see Appendix page 83) illustrates this difference in a three dimension space. The positive surface indicates that the NSW under the noncooperative solution is greater than the NSW under the collusive solution. This difference increases as  $\theta$  and  $\alpha$  increase in the relevant ranges.

By setting  $\theta = 0$ , i.e., constant returns to density, the NSW is reduced to a single variable problem and it becomes straightforward to show that, in equilibrium,  $NSW^{comp} - NSW^{car} > 0$ . In effect, we have that

$$\begin{aligned}
 NSW^{comp} - NSW^{car} > 0 &\iff CS^{comp} + \Pi^{comp} > CS^{car} + \Pi^{car} \\
 &\implies \frac{151\alpha^2 - 464\alpha + 394}{18} > \frac{66\alpha^2 - 204\alpha + 174}{8} \\
 &\implies \alpha^2 - 2\alpha + 1 > 0 \\
 &\implies (\alpha - 1)^2 > 0 \text{ which is always true.}
 \end{aligned}$$

The results obtained in this section indicate that, given the assumptions of the model, it would be socially desirable to set a more competitive environment on intra-European routes when airlines operate H&S networks. Therefore, this result suggests that the establishment of more competition on the intra-European routes<sup>35</sup>, even without new entrants, should be encouraged.

## 2.6 The Merger Solution

Until the late 80s., the strategic response from the EU airlines to an increasingly liberalised, competitive worldwide market, was essentially that of cooperation. This cooperation took mainly the form of (technical) collaboration and partnership among established European flag-carriers together with major airlines from the U.S. and other continents. Recently, the current trend of consolidation in the European airline industry suggests that the flag-carriers' strategies are a) to absorb the small, principally domestic, regional airlines and b) to form cross-border flag-carriers mergers<sup>36</sup>. Whereas the main goal for taking over regional airlines is to "feed" central hub airports by regional traffic, incentives for cross-border mergers are more directly related to achieving higher levels of efficiency. This is particularly true for mergers involving medium-sized flag-carriers, where specialists and airline managers recognise that the prospects for cost savings are impressive<sup>37</sup>.

Since the second type of merger is likely to become an important issue in the EU airline industry (and the recent Swissair's acquisition of a 49.5 % stake

<sup>35</sup>As the introduction of the Third Package is supposed to bring about.

<sup>36</sup>Former Air France Chairman, B. Attali, recently reported that "cannibalism has become a strategic model in this industry". (Fortune Magazine, 2 Nov. 1992, p.26.)

<sup>37</sup>For an airline specialist view see, for example, the Economist, 13 Nov. 1993, p.70. and H. Carnegie & I. Rodger in Financial Times, 24 Nov. 1993. According to an internal Swissair's document, the cost savings from a merger with Austrian Airlines, SAS and KLM (the project is known as Alcazar) could account for 1100 million Ecus in 1997. According to KLM Annual Report (1992/93), this hypothetical merger should principally a) achieve a greater efficiency and lower cost levels at the four airlines, b) strengthen the joint market position of the partners based on various European hubs and c) form a customer-driven global route network. It should be stressed that the negotiations for this merger failed in 1994, but opportunities for a merger involving fewer partners are still open at the moment.

in Sabena attests to this fact), this section deals with the cross-border merger problem. Given the framework developed in Section 2.4, let us suppose that, in response to a more liberal environment, the two H&S airlines (Airline 1 and Airline 2) decide to merge and form a (cross-border) common entity. Should the EU regulatory authority approve the merger of these two flag-carriers and therefore authorise the formation of a monopoly over the entire network ? What are the effects of the elimination of competition on the intra-European leg ? What are the spillovers on the other markets ? The purpose of the following analysis is to explore these important questions.

Farell & Shapiro [1990] demonstrate that, in general, horizontal mergers in Cournot oligopoly raise prices if they generate no synergies between the merging firms. The important theoretical analysis of airline mergers is due to Brueckner & Spiller [1991]. Under some conditions, they show that a) the merger of a hub airline and a nonhub competitor may raise the social welfare, and b) in a network, the merger may lead to welfare gains outside the markets which are of primary concern with the increase in market power. Borenstein [1990] has studied the effect on airfares of two U.S. airlines mergers: The TWA-Ozark and Northwest-Republic mergers. He finds a significant increase in airfares on routes affected by the Northwest-Republic merger, but no evidence of fare increases associated with the TWA-Ozark merger. Kim & Singal's [1993] paper provides insights into how market power and efficiency gains interact in U.S. airline mergers. They find that, in general, airline mergers during the 1985-1988 sample period led to higher fares on routes affected by the merger, creating wealth transfers from consumers. However, according to these authors, most of the effect of increased market power takes place during the merger discussion. Once the merger is completed, they find, in fact, that the efficiency gains offset much of the impact of increased market power (at least when mergers do not involve financially distressed airlines). In effect, they report that (p.567)

*... "Efficiency gains start to kick in after merger completion, mainly for routes with potential sources of direct operating synergies, such as routes on which the merging firms have common hubs or provide overlapping service. For these routes, efficiency gains offset much of the impact of increased market power."*

In the present model, the potential efficiency gains stemming from the merger are simply captured by the increase in traffic densities on the **overlapping** intra-European leg. Following Kim & Singal's [1993] terminology, because prior to the merger the airlines operated an overlapping leg without a common hub, it is likely that "*in the air*" synergies<sup>38</sup> arise from the use of fewer aircraft and/or a better load factor, i.e., capacity utilisation<sup>39</sup>. Therefore, the interesting question is: How much economies of density (and corresponding demand level) are needed for a

<sup>38</sup>In contrast, "*on the ground*" synergies arise from better use of gates/slots and ground crews.

<sup>39</sup>In this model, since both airlines are equally efficient, a merger does not offer an opportunity to rationalise production in the traditional sense, i.e., without changing the total level of output,

merger to increase output and reduce price with respect to the noncooperative solution ? In other words, how much efficiency gains due to higher load factors should the merger generate in order to offset the effects of exercising additional market power by virtue of reducing the number of competitors by one?

Let us assume that because of the network complementarity (see Figure 2.1), the merged airline, Airline  $M$ , operates on the same network structure. In particular, it maintains the two separate and specialised hubs<sup>40</sup>. Again, in order to provide a simple comparison with the previous solutions, I assume the following demand and cost specifications:

$$P(Q_{ij}) = \alpha - \frac{Q_{ij}}{2} \quad \text{with } i = A, B, H, S, Z, Y \quad \text{and } j = A, B, H, S, Z, Y. \quad (2.43)$$

with  $i \neq j$  and  $\alpha > 0$ ;

$$C = \sum_l C_l(Q_l) = \sum_l \left( Q_l - \frac{\theta(Q_l)^2}{2} \right) \quad \text{with } l = 1, 2, 3, 4, 5. \quad (2.44)$$

Notice that, although (2.43) and (2.44) have the same structure as (2.1) and (2.2), they have been modified in order to take the new merger structure into account. I maintain also the same assumptions on travellers' preferences for intra-European air services (see Section 2.2). In particular, it is assumed that  $Q_{AZ}^D = Q_{AY}^D = Q_{BZ}^D = Q_{BY}^D = 0$ . Consequently, the Airline  $M$ 's problem reduces to maximising

$$\begin{aligned} \Pi^M = & P(Q_{AH})Q_{AH} + P(Q_{AB})Q_{AB} + P(Q_{BH})Q_{BH} + P(Q_{AS})Q_{AS} \\ & + P(Q_{BS})Q_{BS} + P(Q_{HS})Q_{HS} + P(Q_{SZ})Q_{SZ} + P(Q_{ZH})Q_{ZH} \\ & + P(Q_{ZY})Q_{ZY} + P(Q_{YH})Q_{YH} + P(Q_{YS})Q_{YS} \\ & - C_1(Q_{AH} + Q_{AB} + Q_{AS}) - C_2(Q_{BH} + Q_{AB} + Q_{BS}) \\ & - C_3(Q_{HS} + Q_{AS} + Q_{BS} + Q_{ZH} + Q_{YH}) \\ & - C_4(Q_{ZS} + Q_{ZY} + Q_{ZH}) - C_5(Q_{YS} + Q_{YH} + Q_{YZ}). \end{aligned} \quad (2.45)$$

where  $\Pi^M$  is the profit function of the merged airline. Notice from (2.45) that Airline  $M$  generates its revenue from 11 city-pair markets whereas its costs correspond to aircraft flown on five different legs. It should be stressed also that on

---

to shift output to the more efficient airline. Nor is it the case that by combining their aircraft (capital) they would produce more efficiently, since as pointed out by Brueckner & Spiller [1989] the existence of an active rental market for aircraft gives no particular advantage associated with acquiring another airline's capital. Of course, it is clear that the existence of complementary resources (capital) could enhance the efficiency gains stemming from the merger. Increases in efficiency can arise from economies of scale or scope related to aircraft maintenance, marketing and sales services, management, extended network, airport gates acquisition, etc.. To the extent that the model only captures the economies of density, it is likely that the efficiency gains discussed in this section are underestimated.

<sup>40</sup>For instance, city  $H$  could serve as the hub for the southern markets, whereas city  $S$  could serve as the hub for the northern markets. See Oum & Tretheway [1990] for a discussion on the various types of H&S structures.

the intra-European leg, Airline  $M$  carries now all the travellers of the  $HS$  market ( $Q_{HS}$ ) as well as all the connecting travellers ( $Q_{AS} + Q_{BS} + Q_{ZH} + Q_{YH}$ ) using the intra-European leg. Assuming interior solutions, the solution of Airline  $M$  implies that the following 11 first order conditions be satisfied:

$$\frac{\partial \Pi^M}{\partial Q_{AH}} = 0 \implies \alpha - Q_{AH} = 1 - \theta(Q_{AH} + Q_{AB} + Q_{AS}) \quad (2.46)$$

$$\begin{aligned} \frac{\partial \Pi^M}{\partial Q_{AB}} = 0 \implies \alpha - Q_{AB} &= 2 - 2\theta Q_{AB} \\ &\quad - \theta(Q_{AH} + Q_{AS} + Q_{BH} + Q_{BS}) \end{aligned} \quad (2.47)$$

$$\frac{\partial \Pi^M}{\partial Q_{BH}} = 0 \implies \alpha - Q_{BH} = 1 - \theta(Q_{BH} + Q_{AB} + Q_{BS}) \quad (2.48)$$

$$\begin{aligned} \frac{\partial \Pi^M}{\partial Q_{AS}} = 0 \implies \alpha - Q_{AS} &= 2 - 2\theta Q_{AS} \\ &\quad - \theta(Q_{AH} + Q_{AB} + Q_{HS} + Q_{BS} + Q_{ZH} + Q_{YH}) \end{aligned} \quad (2.49)$$

$$\begin{aligned} \frac{\partial \Pi^M}{\partial Q_{BS}} = 0 \implies \alpha - Q_{BS} &= 2 - 2\theta Q_{BS} \\ &\quad - \theta(Q_{BH} + Q_{AB} + Q_{HS} + Q_{AS} + Q_{ZH} + Q_{YH}) \end{aligned} \quad (2.50)$$

$$\frac{\partial \Pi^M}{\partial Q_{HS}} = 0 \implies \alpha - Q_{HS} = 1 - \theta(Q_{HS} + Q_{AS} + Q_{BS} + Q_{ZH} + Q_{YH}) \quad (2.51)$$

$$\frac{\partial \Pi^M}{\partial Q_{ZS}} = 0 \implies \alpha - Q_{ZS} = 1 - \theta(Q_{ZS} + Q_{ZY} + Q_{ZH}) \quad (2.52)$$

$$\begin{aligned} \frac{\partial \Pi^M}{\partial Q_{ZY}} = 0 \implies \alpha - Q_{ZY} &= 2 - 2\theta Q_{ZY} \\ &\quad - \theta(Q_{ZS} + Q_{ZH} + Q_{YS} + Q_{YH}) \end{aligned} \quad (2.53)$$

$$\frac{\partial \Pi^M}{\partial Q_{YS}} = 0 \implies \alpha - Q_{YS} = 1 - \theta(Q_{YS} + Q_{YH} + Q_{YZ}) \quad (2.54)$$

$$\begin{aligned} \frac{\partial \Pi^M}{\partial Q_{ZH}} = 0 \implies \alpha - Q_{ZH} &= 2 - 2\theta Q_{ZH} \\ &\quad - \theta(Q_{ZS} + Q_{ZY} + Q_{YH} + Q_{HS} + Q_{AS} + Q_{BS}) \end{aligned} \quad (2.55)$$

$$\begin{aligned} \frac{\partial \Pi^M}{\partial Q_{YH}} = 0 \implies \alpha - Q_{YH} &= 2 - 2\theta Q_{YH} \\ &\quad - \theta(Q_{YS} + Q_{ZY} + Q_{ZH} + Q_{HS} + Q_{AS} + Q_{BS}). \end{aligned} \quad (2.56)$$

Solving the system (2.46)-(2.56) yields the optimal quantities offered by the merged airline. These optimal quantities are

$$Q_{HS} \equiv Q_0^M = \frac{\alpha(1 - 4\theta + 8\theta^2) - 1}{16\theta^2 - 9\theta + 1} \quad (2.57)$$

$$Q_{AH} = Q_{BH} = Q_{ZS} = Q_{YS} \equiv Q_1^M = \frac{\alpha(1 - 6\theta + 6\theta^2) + 4\theta - 1}{16\theta^2 - 9\theta + 1} \quad (2.58)$$

$$Q_{AS} = Q_{BS} = Q_{ZH} = Q_{YH} \equiv Q_2^M = \frac{(1 - 2\theta)(\alpha(1 + \theta) - 2)}{16\theta^2 - 9\theta + 1} \quad (2.59)$$

$$Q_{AB} = Q_{ZY} \equiv Q_3^M = \frac{(1 - 4\theta)(\alpha(1 + \theta) - 2)}{16\theta^2 - 9\theta + 1}. \quad (2.60)$$

Consequently, the Airline  $M$ 's problem is reduced to a four variables problem. Notice that, in contrast to the previous solutions, (2.57) corresponds to the total traffic in the  $HS$  city-pair market. In the Appendix (Section 2.10.8), it is shown that the second order conditions are satisfied as long as  $\theta \leq \frac{9-\sqrt{17}}{32} \cong 0.1524$  (see (2.74)). Moreover, in order to have both positive quantities and marginal revenues(costs), we must ensure that in equilibrium the following inequalities hold

$$\frac{2}{1 + \theta} < \alpha < \frac{1}{\theta(5 - 8\theta)}. \quad (2.61)$$

Hereafter, I assume that both (2.61) and (2.74) are satisfied in equilibrium. Under these conditions, we have that (2.57)-(2.60) are increasing in the demand parameter  $\alpha$ .

**Proposition 6** *As long as  $\theta \in [0, 0.1524]$  and inequalities (2.61) hold, we have that  $Q_0^M \geq Q_1^M$ . PROOF see Appendix.*

Proposition 6 suggests that, for a given nonstop market, the traffic transported on the  $HS$  city-pair market is higher than the traffic in any other city-pair market. This intuitive result can be explained by the position of the cities  $H$  and  $S$  in the network. Airline  $M$ , as unique operator of the central leg of the network (the leg 3 connects the two hubs), is able to achieve higher economies of density, reducing, ceteris paribus, the cost(price) of this leg. Actually, it is interesting to note that the noncooperative solution offered the same qualitative result (see Proposition 3).

**Proposition 7** *As long as  $\theta \in [0, 0.1524]$  and inequalities (2.61) hold, we have that  $Q_2^M \geq Q_3^M$ . PROOF see Appendix.*

Consequently, Proposition 7 suggests that, for a given one stop market, the quantity provided on markets connecting two peripheral cities (markets  $AB, ZY$ ) is lower than the quantity provided on markets connecting a peripheral city and the foreign hub (markets  $AS, BS, ZH, YH$ ). Therefore, consumers are, ceteris paribus, better off on these latter markets. This intuitive result is due to the presence of increasing returns to traffic density. Due to its monopoly position in the  $HS$  market, Airline  $M$  is able to transport a higher traffic level on this market, which generates a positive externality on markets using that leg. It is interesting to note that Proposition 7 is the reverse of Proposition 2 and Proposition 4, where we found that, under the collusive and the noncooperative solutions, consumers were better off in the former markets, i.e.,  $AB$  and  $ZY$ .



**Corollary:** Under the (limit) case of constant returns to density ( $\theta = 0$ ), (2.61) implies that  $2 < \alpha$ , we have that  $Q_0^M = Q_1^M = \alpha - 1$ , and  $Q_2^M = Q_3^M = \alpha - 2$ .

Therefore, in equilibrium, when  $\theta = 0$ , Airline  $M$  provides the same quantity on the nonstop city-pair markets ( $Q_0^M = Q_1^M$ ). As expected, a lower quantity is provided in longer journey markets, i.e., on markets routing through two legs. Moreover, in these latter markets, the quantity provided is identical ( $Q_2^M = Q_3^M$ ).

Finally, it can easily be shown that, in equilibrium,

$$P(Q_1^M) + P(Q_0^M) > P(Q_2^M) \quad \text{and} \quad 2P(Q_1^M) > P(Q_3^M), \quad (2.62)$$

i.e., the usual arbitrage conditions (2.22) hold if the first order conditions (2.46)-(2.56) and the second order conditions (2.74) are satisfied.

## 2.7 The Merger Versus the Noncooperative Solution

In order to give an answer to the questions arising from the preceding section, I propose to compare the noncooperative solution (Section 2.4) with the merger solution (Section 2.6). To this end, I follow the same methodology developed in Section 2.5. A proper comparison implies the restriction of  $\alpha$  in order to satisfy both solutions. In order to satisfy (2.36) and (2.61), the following inequalities must hold

$$\frac{6 - 11\theta}{3 - 3\theta - 4\theta^2} < \alpha < \frac{1}{\theta(5 - 8\theta)}. \quad (2.63)$$

Notice that (2.63) is satisfied for  $\theta \in [0, 0.1479]$ . Consequently, restricting  $\theta$  to  $[0, 0.1479]$ , ensures that all the appropriate conditions of the model, i.e., (2.63), (2.71) and (2.74), are satisfied in equilibrium.

**Proposition 8** *As long as  $\theta \in [0, 0.1479]$  and inequalities (2.63) hold, we have that  $Q_1^M \geq Q_1^{comp}$ ,  $Q_2^M \geq Q_2^{comp}$ ,  $Q_3^M \geq Q_3^{comp}$  and  $Q_0^M > (<) 2Q_0^{comp}$ . PROOF see Appendix.*

Proposition 8 is our second important theoretical result. Given the specification of the model, the merger solution provides an ambiguous result in the  $HS$  market but greater or equal quantities in all other markets. The ambiguous result in the  $HS$  market depends on a complex relation between the returns to density and the demand parameters. It can be shown that when the returns to density are sufficiently strong, i.e.,  $\theta \in [0.093, 0.1479]$  and the demand satisfies  $\alpha^* < \alpha < \frac{1}{\theta(5-8\theta)}$ , the merger solution provides a greater quantity on the  $HS$  market (see the proof in the Appendix). In all the other markets, the merger solution

provides greater or equal quantities with respect to the noncooperative solution, for all values of  $\alpha$  and  $\theta$ .

This second theoretical result deserves some comments. In effect, the model suggests that, for some variety of parameters, the merger solution provides a greater quantity on *all* city-pair markets. To understand the intuition behind this result, it is important to remember that in the noncooperative solution, competition is really effective on the intra-European market  $HS$ <sup>41</sup>. This means that on all the other markets, only one airline actually provides air services. Therefore, in these latter markets, the merger and the noncooperative solutions are, basically, similar in terms of market power. The merged airline provides a larger quantity in these markets, because it is able to exploit the increasing returns to density on the intra-European leg  $HS$ . In fact, the decrease of the marginal cost on that leg has positive effects on the other markets throughout the network (even in those markets which are not routing through the  $HS$  leg). Matters are quite different in the  $HS$  city-pair market, where the market power changes in function of the solution. Not surprisingly, the model suggests that when the efficiency gains (through the returns to density) are sufficiently important ( $0.0925 < \theta < 0.1479$ ) and the demand is relatively strong ( $\alpha > \alpha^*$ ), consumers on the  $HS$  market are better off under the merger solution. Conversely, when the returns to density are relatively weak ( $\theta < 0.0925$ ), the noncooperative outcome is preferred from the  $HS$  consumers' point of view since the quantity(price) is larger(lower). It should be noticed that, when  $\theta < 0.0925$  ( $\theta > 0.139$ ), the noncooperative (merger) outcome is preferred **whether** the demand is weak or strong<sup>42</sup>. Hence, these results emphasise the key role played by the returns to density.

**Corollary:** Under the (limit) case of constant returns to density ( $\theta = 0$ ), (2.63) implies that  $2 < \alpha$ , we have that  $Q_0^M < 2Q_0^{comp}$ ,  $Q_1^M = Q_1^{comp}$ ,  $Q_2^M = Q_2^{comp}$ , and  $Q_3^M = Q_3^{comp}$ .

Therefore, when  $\theta = 0$ , the noncooperative solution provides a greater quantity on the market where competition is effective ( $HS$ ). On the other markets, both solutions provide the same quantities. It should be noticed that under the absence of increasing returns to density, the merger solution mimics the cartel outcome.

In conclusion, Proposition 8 highlights the importance of the network structure in the analysis of an intra-EU airline merger. It suggests that the merger may lead to greater(lower) quantities(prices) on the markets which are not of primary concern with an increase in market power, i.e., ( $Q_1^M$ ,  $Q_2^M$  and  $Q_3^M$ ). Brueckner & Spiller [1991] find a similar result using another H&S structure. Table 2.2 (see Appendix page 82) summarises the results of Proposition 8 for some selected values of  $\theta$  up to 0.147.

<sup>41</sup>By assumption, the model excludes cabotage competition.

<sup>42</sup>These figures are approximated by computer simulation. See Table 2.2 in the Appendix.

The final desirability of the merger is assessed after comparing the NSW under the merger and the noncooperative solutions. Given (2.38) and (2.57)-(2.60), the consumer surplus throughout the network under the merger solution,  $CS^M$ , equals

$$\begin{aligned}
 CS^M(\theta, \alpha) &= \frac{(Q_0^M)^2}{4} + (Q_1^M)^2 + (Q_2^M)^2 + \frac{(Q_3^M)^2}{2} \\
 &= \frac{\alpha^2(11 - 76\theta + 214\theta^2 - 288\theta^3 + 256\theta^4)}{4(16\theta^2 - 9\theta + 1)^2} + \\
 &\quad \frac{-\alpha(34 - 192\theta + 320\theta^2) + 29 - 160\theta + 256\theta^2}{4(16\theta^2 - 9\theta + 1)^2}.
 \end{aligned} \tag{2.64}$$

Given (2.45) and the optimal quantities (2.57)-(2.60), the economic profit of Airline  $M$ , hence of the industry, is

$$\Pi^M(\theta, \alpha) = \frac{\alpha^2(11 - 38\theta + 16\theta^2) - \alpha(34 - 96\theta) + 29 - 80\theta}{2(16\theta^2 - 9\theta + 1)}. \tag{2.65}$$

The NSW under the merger solution,  $NSW^M$ , is obtained by adding (2.64) and (2.65). Unfortunately, the difference between  $NSW^M$  and  $NSW^{comp}$  has not a closed form solution. This difference depends in a complex relation between the parameters of the model ( $\theta$  and  $\alpha$ ). The comparison of  $NSW^M$  and  $NSW^{comp}$  is shown in Table 2.3 (see Appendix page 82) for some selected values of  $\theta$  up to 0.14. It is interesting to note that  $NSW^M$  is superior to  $NSW^{comp}$  when the low returns to density are balanced with a relatively high demand. When the returns to density are relatively important ( $\theta > 0.1$ ), Table 2.3 shows that the merger solution is always preferable from the social welfare point of view.

Figure 2.4 (see Appendix page 84) illustrates this difference in the three dimension space. As expected, the noncooperative solution dominates the merger solution if the returns to density and the demand are relatively weak. An increase in  $\theta$  sustained by a relatively high demand reverses the previous result. When  $\theta > 0.1$  there is no ambiguity, the merger outcome is socially preferable.

By setting  $\theta = 0$ , i.e., constant returns to density, the NSW is reduced to a single variable problem. As expected, in this case the noncooperative solution dominates the merger solution. In effect, we have that

$$\begin{aligned}
 NSW^{comp} - NSW^M > 0 &\iff CS^{comp} + \Pi^{comp} > CS^M + \Pi^M \\
 &\implies \frac{151\alpha^2 - 464\alpha + 394}{18} > \frac{33\alpha^2 - 102\alpha + 87}{4} \\
 &\implies \alpha^2 - 2\alpha + 1 > 0 \\
 &\implies (\alpha - 1)^2 > 0 \quad \text{which is always true.}
 \end{aligned}$$

The results obtained in this section give some insights into the opportunity of a socially desirable cross-border merger. In particular, this model shows that

a merger between two flag-carriers organised in H&S networks may increase the social welfare when the efficiency gains (obtained through the returns to density) are relatively important<sup>43</sup>. Consequently, under increasing returns to density, the threat of monopolisation through the merger should not always be of primary concern to EU antitrust authorities. In addition, given that the markets which directly benefit from the merger ( $Q_1^M, Q_2^M$  and  $Q_3^M$ ) are outside the market of primary concern with an increase in market power ( $Q_0^M$ ), exclusive focus on gains and losses in this latter market may have the effect of blocking socially desirable mergers. This model also suggests that purely domestic consumers should not, a priori, be harmed by such a cross-border merger. Finally, notice that, although it is not a matter of concern to this section, the merger solution dominates the collusive solution for all the values of  $\theta$  and  $\alpha$  allowed by the model.

## 2.8 Conclusion

This chapter provides an analysis of the intra-European airline competition within an explicit (H&S) network. Using the quantity setting paradigm, optimal solutions are derived for various competition scenarios. The model presented in this chapter provides two important results. First, the model clearly suggests that EU authorities should ban bilateral collusive agreements between flag-carriers. Second, the model highlights that under sufficient increasing returns to density, the threat of monopolisation through the merger should not always be of primary concern to EU antitrust authorities. Therefore, although the market power issue is key in this industry, EU antitrust authorities should carefully analyse how the networks are fitted together (network complementarities) and how much efficiency gains due to higher load factors (economies of density) are likely to arise following a merger. In short, a cross-border merger between two flag-carriers should not be rejected as a general rule.

The main results of the paper are likely to hold under a variety of different demand and cost structures because they are driven by the network H&S structure and by the returns to density. The analysis could be extended in the following different directions. First, it would be interesting to see if these results are confirmed under a price setting strategy with product (air service) differentiation. Second, a market specific demand parameter ( $\alpha_{ij}$ ) could be introduced. Third, this model could analyse the potential effects of cabotage competition. In that case, it is assumed that access to domestic routes is open to the foreign flag-carrier. Consequently, flag-carriers lose their “hinterland” and duopolistic competition arises throughout the network. Given that airlines face each other in several markets, it would be interesting to see how they could compete less vigorously in one market due to the fear of retaliation in another. The retaliation argument could also

---

<sup>43</sup>Recently, Röller & Sickles [1993] argue that competition policy in Europe should allow mergers or strategic alliances to be formed if they do translate in costs savings (especially from the elimination of cost inefficiencies) and increased international competitiveness.

play an important role in explaining the lack of entry in new markets. The next chapter documents the lack of entry observed during the first 18 months following the Third Package and presents a model which shows under which conditions the European airline industry is more likely to sustain a (noncooperative) "mutual forbearance" equilibrium.

## 2.9 References

- ANTONIOU, A., 1991, "Economies of Scale in the Airline Industry: The Evidence Revisited," *Logistics and Transportation Review*, 27, pp.159-184.
- BAUER, P.W., 1987, "Airline Hubs: A Study of Determining Factors and Effect," *Federal Reserve Bank of Cleveland Economic Review*, Quarter 4, pp.13-19.
- BETTS, P. and GARDNER, D., 1992, *Financial Times*, 24 June 1992.
- BORENSTEIN, S., 1989, "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry," *Rand Journal of Economics*, 20, pp.344-365.
- BORENSTEIN, S., 1990, "Airline Mergers, Airport Dominance, and Market Power," *American Economic Review*, 80, pp.400-404.
- BORENSTEIN, S., 1991, "The Dominant-Firm Advantage in Multiproduct Industries: Evidence from the U.S. Airlines," *Quarterly Journal of Economics*, 56, pp.1237-1266.
- BORENSTEIN, S., 1992, "The Evolution of U.S. Airline Competition," *Journal of Economic Perspectives*, 6, pp.45-74.
- BRANDER, J.A. and ZHANG, A., 1990, "Market Conduct in the Airline Industry: An Empirical Investigation", *Rand Journal of Economics*, 21, pp.567-583.
- BRANDER, J.A. and ZHANG, A., 1993, "Dynamic Oligopoly Behaviour in the Airline Industry," *International Journal of Industrial Organization*, 11, pp.407-435.
- BRUECKNER, J.K. and SPILLER, P.T., 1991, "Competition and Mergers in Airline Networks," *International Journal of Industrial Organization*, 9, pp.323-342.
- BRUECKNER, J.K. and SPILLER, P.T., 1994, "Economies of Traffic Density in the Deregulated Airline Industry," *Journal of Law and Economics*, 37, pp.379-415.

- CARLTON, D.W., LANDES W.M. and POSNER, R.A.**, 1980, "Benefits and Costs of Airline Mergers: A Case Study," *Bell Journal of Economics*, 11, pp.65-83.
- CAVES, D.W., CHRISTENSEN, L.R. and TRETHERWAY, M.W.**, 1984, "Economies of Density versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ," *Rand Journal of Economics*, 15, pp.471-489.
- DAUGHETY, A.F.**, 1985, "Transportation Research on Pricing and Regulation: Overview and Suggestions for Future Research," *Transportation Research Part-A*, 19, pp.471-487.
- DOGANIS, R.**, 1985, *Flying off Course: The Economics of International Airlines*, George Allen & Unwin Ltd, London.
- FARRELL, J. and SHAPIRO, C.**, 1990, "Horizontal Mergers: An Equilibrium Analysis," *American Economic Review*, 80, pp.107-126.
- HENDRICKS, K., PICCIONE, M. and TAN, G.**, 1995, "The Economics of Hubs: The Case of Monopoly," *Review of Economic Studies*, 62, pp.83-99.
- KIM, E.H. and SINGAL, V.**, 1993, "Mergers and Market Power: Evidence from the Airline Industry," *American Economic Review*, 83, pp.549-569.
- LEVINE, M.E.**, 1987, "Airline Competition in a Deregulated Market: Theory, Firm Strategy, and Public Policy," *Yale Journal on Regulation*, 4, pp.393-494.
- OUM, T.H. and TRETHERWAY, M.W.**, 1990, "Airline Hub-and-Spoke Systems," *Transportation Research Forum*, 90, pp.380-393.
- PAVAUX, J.**, 1984, *L'Economie du Transport Aérien: la Concurrence Impraticable*, Economica, Paris.
- REISS, P.C. and SPILLER, P.T.**, 1989, "Competition and Entry in Small Airline Markets," *Journal of Law and Economics*, 32, pp.S179-S202.
- RÖLLER, L-H. and SICKLES, R.C.**, 1993, *Competition, Market Niches, and Efficiency: A Structural Model of the European Airline Industry*, Mimeo, December.
- SÄRNDAL, C. and STATTON, W.B.**, 1975, "Factors Influencing Operating Cost in the Airline Industry," *Journal of Transport Economics and Policy*, 9, pp.67-88.
- STARR, R.M. and STINCHCOMBE, M.B.**, 1992, *Efficient Transportation Routing and Natural Monopoly in the Airline Industry: An Economic Analysis of Hub-Spoke and Related Systems*, Working Paper, No.92-25, University of San Diego.

## 2.10 Appendix

### 2.10.1 Second Order Conditions for the Collusive Solution

In fact, given (2.17)-(2.20), the cartel profit,  $\Pi^{car} = \Pi_1 + \Pi_2$  can be simplified to the following expression

$$\begin{aligned}\Pi^{car} = & 2(\alpha - Q_0)Q_0 + 4(\alpha - \frac{Q_1}{2})Q_1 + 4(\alpha - \frac{Q_2}{2})Q_2 + 2(\alpha - \frac{Q_3}{2})Q_3 \\ & - 4(Q_1 + Q_2 + Q_3 - \frac{\theta(Q_1 + Q_2 + Q_3)^2}{2}) \\ & - 2(Q_0 + 2Q_2 - \frac{\theta(Q_0 + 2Q_2)^2}{2}).\end{aligned}\quad (2.66)$$

From (2.66), it turns out that second order conditions reduce to the following symmetric Hessian matrix

$$\begin{vmatrix} \theta - 2 & 0 & 2\theta & 0 \\ 0 & 2(\theta - 1) & 2\theta & 2\theta \\ 2\theta & 2\theta & 2(3\theta - 1) & 2\theta \\ 0 & 2\theta & 2\theta & 2\theta - 1 \end{vmatrix}\quad (2.67)$$

The maximisation of (2.66) requires (2.67) to be negative semidefinite<sup>44</sup>. This condition is verified if and only if the principal minor determinants of order  $q$  have sign  $(-1)^q$  for  $q = 1, 2, 3, 4$ . It can be easily verified that the sign of the principal minor determinants of (2.67) properly alternates if

$$16\theta^2 - 13\theta + 2 \geq 0. \quad (2.68)$$

This holds for any  $\theta \leq \frac{13-\sqrt{41}}{32} \cong 0.2062$ <sup>45</sup>. It should be noticed that the quadratic function (2.68) corresponds to the denominator of the optimal quantities (2.17)-(2.20).

### 2.10.2 Proof of Proposition 1

#### Proof 1

$$\begin{aligned}Q_1^{car} \geq 2Q_0^{car} & \iff \frac{(2-3\theta)(\alpha(1-2\theta)-1)}{16\theta^2-13\theta+2} \geq \frac{(2-4\theta)(\alpha(1-2\theta)-1)}{16\theta^2-13\theta+2} \\ & \implies \theta \geq 0 \text{ since } \alpha > \frac{1}{1-2\theta} \text{ under (2.21)} \quad \square.\end{aligned}$$

..

<sup>44</sup>See Varian [1992].

<sup>45</sup>Given that this quadratic function admits two roots, I assume that  $\theta \in [0, 0.2062]$ . Actually, this restriction is consistent with the empirical findings provided by Caves et al.[1984].

### 2.10.3 Proof of Proposition 2

**Proof 2**

$$\begin{aligned}
 Q_3^{car} \geq Q_2^{car} &\iff \frac{\alpha(2 - 4\theta^2 - \theta) + 6\theta - 4}{16\theta^2 - 13\theta + 2} \geq \frac{\alpha(2 - 2\theta^2 - 2\theta) + 7\theta - 4}{16\theta^2 - 13\theta + 2} \\
 &\implies \theta(\alpha(1 - 2\theta) - 1) \geq 0 \\
 &\implies \theta \geq 0 \text{ since } \alpha > \frac{1}{1 - 2\theta} \text{ under (2.21)} \quad \square.
 \end{aligned}$$

### 2.10.4 Second Order Conditions for the Noncooperative Solution

As previously, using (2.1) and (2.2) and (2.32)-(2.35), the Airline's 1 problem (2.24) reduces to maximising the following expression

$$\begin{aligned}
 \Pi_1 = & (\alpha - Q_0)Q_0 + 2(\alpha - \frac{Q_1}{2})Q_1 + 2(\alpha - \frac{Q_2}{2})Q_2 + (\alpha - \frac{Q_3}{2})Q_3 \\
 & - 2(Q_1 + Q_2 + Q_3 - \frac{\theta(Q_1 + Q_2 + Q_3)^2}{2}) \\
 & - (Q_0 + 2Q_2 - \frac{\theta(Q_0 + 2Q_2)^2}{2}).
 \end{aligned} \tag{2.69}$$

Consequently, the second order conditions from (2.69) reduce to the following symmetric Hessian matrix

$$\begin{vmatrix}
 \theta - 2 & 0 & 2\theta & 0 \\
 0 & 2(\theta - 1) & 2\theta & 2\theta \\
 2\theta & 2\theta & 2(3\theta - 1) & 2\theta \\
 0 & 2\theta & 2\theta & 2\theta - 1
 \end{vmatrix} \tag{2.70}$$

It should be notice that this matrix is similar to (2.67). As a consequence, (2.70) is negative semidefinite if (2.68) is verified, i.e., if  $16\theta^2 - 13\theta + 2 \geq 0$ . For computational convenience, I restrict  $\theta$  in order to have positive quantities. This is, in part, satisfied if the denominator in (2.32)-(2.35) is positive, i.e., if

$$26\theta^2 - 20\theta + 3 > 0. \tag{2.71}$$

In turn, this implies  $\theta < \frac{20 - \sqrt{88}}{52} \cong 0.2042$  <sup>46</sup>.

### 2.10.5 Proof of Proposition 3

**Proof 3**

$$2Q_0^{comp} > Q_1^{comp} \iff \frac{(4 - 8\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3} > \frac{(3 - 5\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3}$$

<sup>46</sup>Actually, it can be noticed that this figure is very close to the figure of condition (2.68), i.e.,  $\theta < 0.2062$ .



$$\begin{aligned} &\Rightarrow (4 - 8\theta) > (3 - 5\theta) \quad \text{since } \alpha > \frac{1}{1 - 2\theta} \quad \text{under (2.36),} \\ &\Rightarrow \theta < \frac{1}{3} \quad \square. \end{aligned}$$

### 2.10.6 Proof of Proposition 4

**Proof 4**

$$\begin{aligned} Q_3^{comp} \geq Q_2^{comp} &\iff \frac{\alpha(3 - 2\theta - 6\theta^2) + 10\theta - 6}{26\theta^2 - 20\theta + 3} \geq \frac{\alpha(3 - 3\theta - 4\theta^2) + 11\theta - 6}{26\theta^2 - 20\theta + 3} \\ &\Rightarrow \theta(\alpha(1 - 2\theta) - 1) \geq 0 \\ &\Rightarrow \theta \geq 0 \quad \text{since } \alpha \geq \frac{1}{1 - 2\theta} \quad \text{under (2.36)} \quad \square. \end{aligned}$$

### 2.10.7 Proof of Proposition 5

**Proof 5**

$$\begin{aligned} 2Q_0^{comp} > 2Q_0^{car} &\iff \frac{(4 - 8\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3} > \frac{(2 - 4\theta)(\alpha(1 - 2\theta) - 1)}{16\theta^2 - 13\theta + 2} \\ &\Rightarrow 2(16\theta^2 - 13\theta + 2) > 26\theta^2 - 20\theta + 3 \\ &\Rightarrow 6\theta^2 - 6\theta + 1 > 0 \quad \text{which is satisfied for } \theta \in [0, 0.2113]. \end{aligned}$$

$$\begin{aligned} Q_1^{comp} \geq Q_1^{car} &\iff \frac{(3 - 5\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3} \geq \frac{(2 - 3\theta)(\alpha(1 - 2\theta) - 1)}{16\theta^2 - 13\theta + 2} \\ &\Rightarrow (3 - 5\theta)(16\theta^2 - 13\theta + 2) \geq (2 - 3\theta)(26\theta^2 - 20\theta + 3) \\ &\Rightarrow \theta^2(1 - 2\theta) \geq 0 \\ &\Rightarrow \theta \leq \frac{1}{2}. \end{aligned}$$

$$\begin{aligned} Q_2^{comp} \geq Q_2^{car} &\iff \frac{\alpha(3 - 3\theta - 4\theta^2) + 11\theta - 6}{26\theta^2 - 20\theta + 3} \geq \frac{\alpha(2 - 2\theta^2 - 2\theta) + 7\theta - 4}{16\theta^2 - 13\theta + 2} \\ &\Rightarrow \theta(1 - 2\theta)(1 - 3\theta)[\alpha(1 - 2\theta) - 1] \geq 0 \\ &\Rightarrow \alpha \geq \frac{1}{1 - 2\theta} \quad \text{which is true under (2.37).} \end{aligned}$$

$$\begin{aligned} Q_3^{comp} \geq Q_3^{car} &\iff \frac{\alpha(3 - 2\theta - 6\theta^2) + 10\theta - 6}{26\theta^2 - 20\theta + 3} \geq \frac{\alpha(2 - 4\theta^2 - \theta) + 6\theta - 4}{16\theta^2 - 13\theta + 2} \\ &\Rightarrow 2\theta^2(1 - 2\theta)[\alpha(1 - 2\theta) - 1] \geq 0 \\ &\Rightarrow \alpha \geq \frac{1}{1 - 2\theta} \quad \text{which is true under (2.37)} \quad \square. \end{aligned}$$

### 2.10.8 Second Order Conditions for the Merger Solution

Using (2.57)-(2.60), the Airline  $M$ 's problem (2.45) can be simplified to the following expression

$$\begin{aligned}\Pi^M = & (\alpha - \frac{Q_0}{2})Q_0 + 4(\alpha - \frac{Q_1}{2})Q_1 + 4(\alpha - \frac{Q_2}{2})Q_2 + 2(\alpha - \frac{Q_3}{2})Q_3 \\ & - 4(Q_1 + Q_2 + Q_3 - \frac{\theta(Q_1 + Q_2 + Q_3)^2}{2}) \\ & - (Q_0 + 4Q_2 - \frac{\theta(Q_0 + 4Q_2)^2}{2}).\end{aligned}\quad (2.72)$$

Although similar to the joint profit maximisation problem (2.66), it is important to stress that (2.72) corresponds to a different expression. It turns out that the second order conditions from (2.72) reduce to the following symmetric Hessian matrix

$$\begin{vmatrix} \theta - 1 & 0 & 4\theta & 0 \\ 0 & 4(\theta - 1) & 4\theta & 4\theta \\ 4\theta & 4\theta & 4(5\theta - 1) & 4\theta \\ 0 & 4\theta & 4\theta & 2(2\theta - 1) \end{vmatrix} \quad (2.73)$$

It can be shown that (2.73) is negative semidefinite if

$$16\theta^2 - 9\theta + 1 > 0. \quad (2.74)$$

This holds for any  $\theta \leq \frac{9-\sqrt{17}}{32} \cong 0.1524$ <sup>47</sup>. It should be pointed out that (2.74) corresponds to the denominator of the optimal quantities (2.57)-(2.60).

### 2.10.9 Proof of Proposition 6

**Proof 6**

$$\begin{aligned}Q_0^M \geq Q_1^M & \iff \frac{\alpha(1 - 4\theta + 8\theta^2) - 1}{16\theta^2 - 9\theta + 1} \geq \frac{(\alpha(1 - 6\theta + 6\theta^2) + 4\theta - 1)}{16\theta^2 - 9\theta + 1} \\ & \implies \theta \geq 0 \text{ since } \alpha > \frac{2}{1 + \theta} \text{ under (2.61)} \quad \square.\end{aligned}$$

### 2.10.10 Proof of Proposition 7

**Proof 7**

$$\begin{aligned}Q_2^M \geq Q_3^M & \iff \frac{(1 - 2\theta)(\alpha(1 + \theta) - 2)}{16\theta^2 - 9\theta + 1} \geq \frac{(1 - 4\theta)(\alpha(1 + \theta) - 2)}{16\theta^2 - 9\theta + 1} \\ & \implies \theta \geq 0 \text{ since } \alpha > \frac{2}{1 + \theta} \text{ under (2.61)} \quad \square.\end{aligned}$$

---

<sup>47</sup>Given that this quadratic function admits two roots, I assume that  $\theta \in [0, 0.1524]$ .

### 2.10.11 Proof of Proposition 8

Proof 8

$$\begin{aligned}
Q_1^M \geq Q_1^{comp} &\iff \frac{\alpha(1 - 6\theta + 6\theta^2)}{16\theta^2 - 9\theta + 1} \geq \frac{(3 - 5\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3} \\
&\implies \alpha(7 - 10\theta - 4\theta^2) - 13 + 24\theta \geq 0 \\
&\implies \alpha \geq \frac{13 - 24\theta}{7 - 10\theta - 4\theta^2} \quad \text{which is always true under (2.63).} \\
\\
Q_2^M \geq Q_2^{comp} &\iff \frac{(1 - 2\theta)(\alpha(1 + \theta) - 2)}{16\theta^2 - 9\theta + 1} \geq \frac{\alpha(3 - 3\theta - 4\theta^2) + 11\theta - 6}{26\theta^2 - 20\theta + 3} \\
&\implies \alpha(7 - 10\theta - 4\theta^2) - 13 + 24\theta \geq 0 \\
&\implies \alpha \geq \frac{13 - 24\theta}{7 - 10\theta - 4\theta^2} \quad \text{which is always true under (2.63).} \\
\\
Q_3^M \geq Q_3^{comp} &\iff \frac{(1 - 4\theta)(\alpha(1 + \theta) - 2)}{16\theta^2 - 9\theta + 1} \geq \frac{\alpha(3 - 2\theta - 6\theta^2) + 10\theta - 6}{26\theta^2 - 20\theta + 3} \\
&\implies \alpha(7 - 10\theta - 4\theta^2) - 13 + 24\theta \geq 0 \\
&\implies \alpha \geq \frac{13 - 24\theta}{7 - 10\theta - 4\theta^2} \quad \text{which is always true under (2.63).} \\
\\
Q_0^M > 2Q_0^{comp} &\iff \frac{\alpha(1 - 4\theta + 8\theta^2) - 1}{16\theta^2 - 9\theta + 1} > \frac{(4 - 8\theta)(\alpha(1 - 2\theta) - 1)}{26\theta^2 - 20\theta + 3} \\
&\implies \alpha > \frac{1 - 24 + 110\theta^2 - 128\theta^3}{1 - 20\theta + 94\theta^2 - 136\theta^3 + 48\theta^4} = \alpha^* \quad \text{for } \theta > 0.0717 \quad \square.
\end{aligned}$$

Table 2.1: Comparison of Noncooperative and Cartel Equilibria

	Proper solutions require	Outcome
$\theta = 0$	$2 < \alpha < \infty$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} = Q_1^{car}, Q_2^{comp} = Q_2^{car}, Q_3^{comp} = Q_3^{car}$
$\theta = 0.02$	$1.970 < \alpha < 16.71$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.04$	$1.941 < \alpha < 8.373$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.06$	$1.912 < \alpha < 5.597$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.08$	$1.883 < \alpha < 4.209$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.10$	$1.854 < \alpha < 3.378$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.12$	$1.825 < \alpha < 2.825$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.14$	$1.797 < \alpha < 2.430$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.16$	$1.768 < \alpha < 2.135$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.18$	$1.739 < \alpha < 1.906$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$
$\theta = 0.20$	$1.710 < \alpha < 1.724$	$Q_0^{comp} > Q_0^{car}, Q_1^{comp} > Q_1^{car}, Q_2^{comp} > Q_2^{car}, Q_3^{comp} > Q_3^{car}$

..

Table 2.2: Comparison of Merger and Noncooperative Equilibria

	Proper solutions require	Outcome	
$\theta = 0$	$2 < \alpha < \infty$	$Q_0^M < 2Q_0^{comp}$	$Q_1^M = Q_1^{comp}, Q_2^M = Q_2^{comp}, Q_3^M = Q_3^{comp}$
$\theta = 0.02$	$1.967 < \alpha < 10.33$	$Q_0^M < 2Q_0^{comp}$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.04$	$1.935 < \alpha < 5.342$	$Q_0^M < 2Q_0^{comp}$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.06$	$1.903 < \alpha < 3.687$	$Q_0^M < 2Q_0^{comp}$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.08$	$1.872 < \alpha < 2.867$	$Q_0^M < 2Q_0^{comp}$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.09$	$1.857 < \alpha < 2.596$	$Q_0^M < 2Q_0^{comp}$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.10$	$1.842 < \alpha < 2.380$	$Q_0^M < 2Q_0^{comp}$ if $\alpha < 2.234$ $Q_0^M > 2Q_0^{comp}$ if $\alpha > 2.234$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.11$	$1.827 < \alpha < 2.207$	$Q_0^M < 2Q_0^{comp}$ if $\alpha < 2.026$ $Q_0^M > 2Q_0^{comp}$ if $\alpha > 2.026$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.12$	$1.812 < \alpha < 2.063$	$Q_0^M < 2Q_0^{comp}$ if $\alpha < 1.905$ $Q_0^M > 2Q_0^{comp}$ if $\alpha > 1.905$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.13$	$1.798 < \alpha < 1.943$	$Q_0^M < 2Q_0^{comp}$ if $\alpha < 1.829$ $Q_0^M > 2Q_0^{comp}$ if $\alpha > 1.829$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.14$	$1.783 < \alpha < 1.841$	$Q_0^M > 2Q_0^{comp}$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$
$\theta = 0.147$	$1.773 < \alpha < 1.779$	$Q_0^M > 2Q_0^{comp}$	$Q_1^M > Q_1^{comp}, Q_2^M > Q_2^{comp}, Q_3^M > Q_3^{comp}$

Table 2.3:  $NSW^M$  Versus  $NSW^{comp}$

	Proper solutions require	Outcome
$\theta = 0$	$2 < \alpha < \infty$	$NSW^{comp} > NSW^M$
$\theta = 0.02$	$1.967 < \alpha < 10.33$	$NSW^{comp} > NSW^M$ if $\alpha < 3.418$ $NSW^{comp} < NSW^M$ if $\alpha > 3.418$
$\theta = 0.04$	$1.935 < \alpha < 5.342$	$NSW^{comp} > NSW^M$ if $\alpha < 2.314$ $NSW^{comp} < NSW^M$ if $\alpha > 2.314$
$\theta = 0.06$	$1.903 < \alpha < 3.687$	$NSW^{comp} > NSW^M$ if $\alpha < 2.058$ $NSW^{comp} < NSW^M$ if $\alpha > 2.058$
$\theta = 0.08$	$1.872 < \alpha < 2.867$	$NSW^{comp} > NSW^M$ if $\alpha < 1.934$ $NSW^{comp} < NSW^M$ if $\alpha > 1.934$
$\theta = 0.10$	$1.842 < \alpha < 2.380$	$NSW^{comp} > NSW^M$ if $\alpha < 1.853$ $NSW^{comp} < NSW^M$ if $\alpha > 1.853$
$\theta = 0.11$	$1.827 < \alpha < 2.207$	$NSW^{comp} < NSW^M$
$\theta = 0.12$	$1.812 < \alpha < 2.063$	$NSW^{comp} < NSW^M$
$\theta = 0.13$	$1.798 < \alpha < 1.943$	$NSW^{comp} < NSW^M$
$\theta = 0.14$	$1.783 < \alpha < 1.841$	$NSW^{comp} < NSW^M$

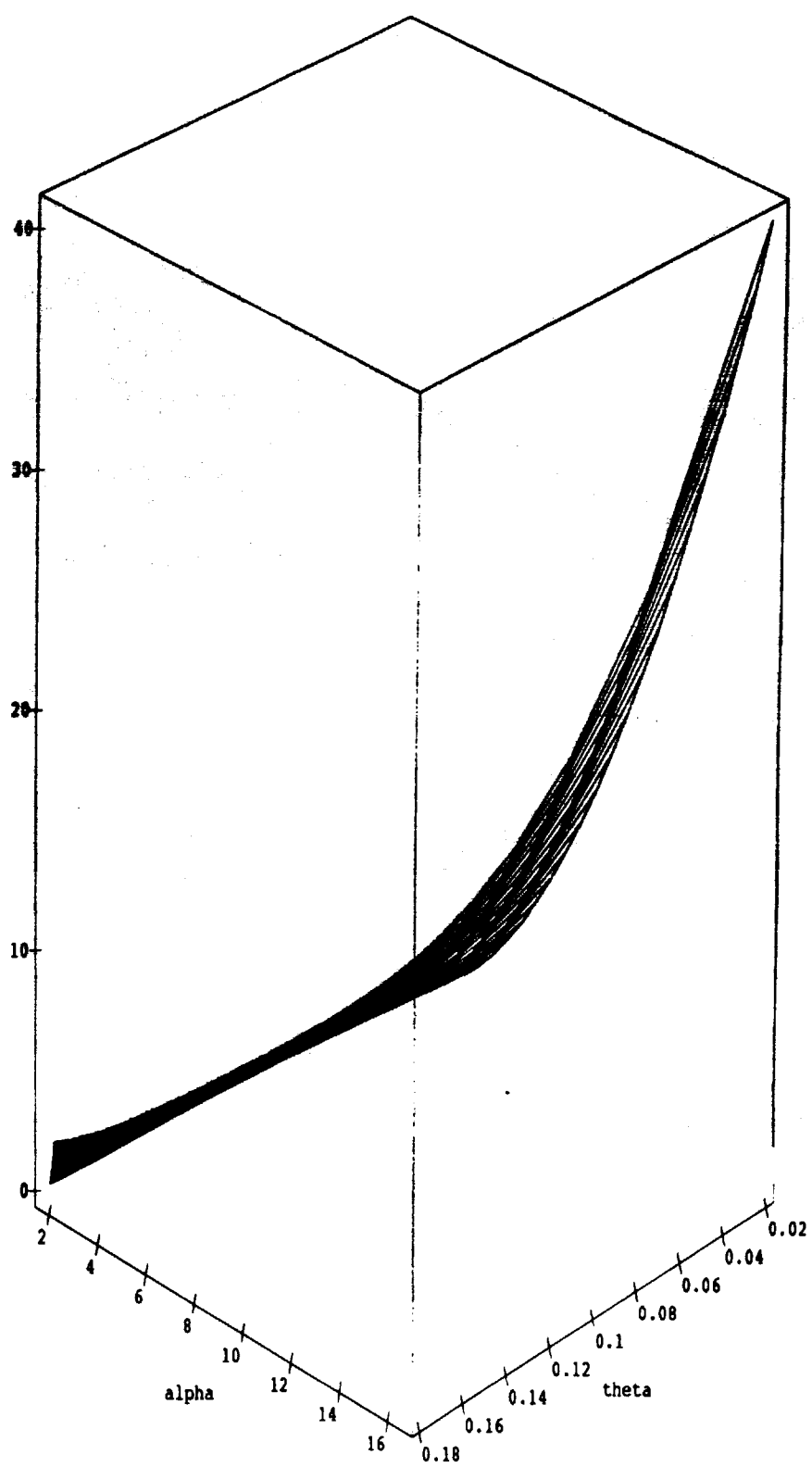


Figure 2.3:  $NSW^{comp} - NSW^{car}$

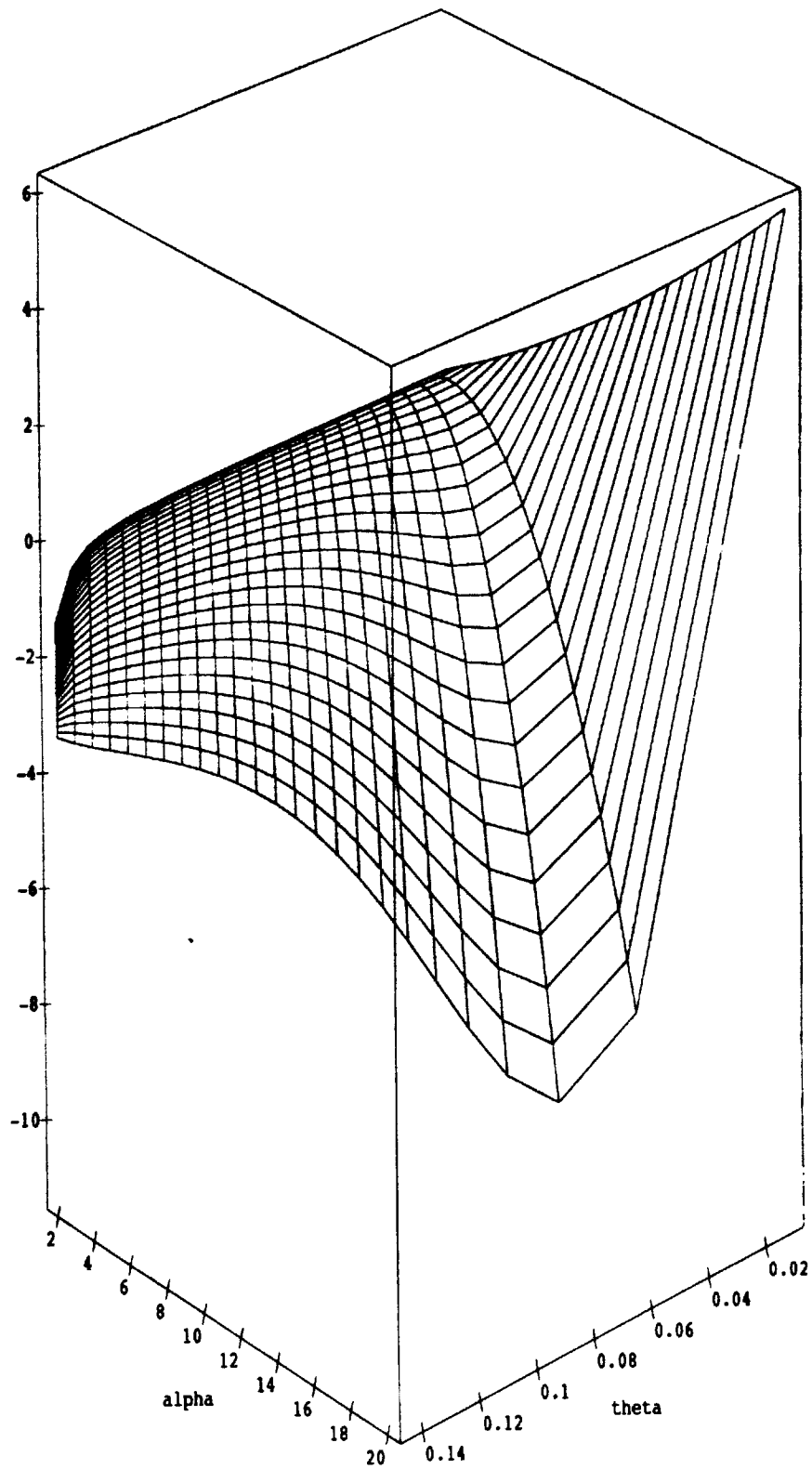


Figure 2.4:  $NSW^{comp} - NSW^M$

## Chapter 3

# Third Package, Lack of Entry and Noncooperative Collusion in the European Airline Industry

### 3.1 Introduction

An incumbent firm may preclude entry by a rival into a market by attacking this rival in (all) the other markets in which the rival already operates. This not an unfamiliar result to economists (Kahn [1950], Edwards [1955]). When one firm might be better off by avoiding another's "territory" for fear of retaliation, we may end up in a "mutual forbearance" equilibrium for the industry. This kind of equilibrium is more likely to happen when oligopolists compete in different markets and meet each other repeatedly (Bernheim & Whinston [1990]).

The airline industry provides an ideal framework to study these strategic issues. Empirical research suggests that strategic effects play a substantial role in the conduct and performance of the U.S. airline industry (Evens & Kessides [1993,1994], Barla [1992]). However, there has been little theoretical work to relate these strategic effects to specific features of the industry, in particular the fact that airlines operate networks. It has been recognised that the structure of airlines' network plays an important role in understanding airline economics (Pavoux [1984], Levine [1987]). Recent research has confirmed that hub-and-spoke networks operated by airlines are an efficient way to organise production (e.g., Encaoua & Perrot [1991]) and that the effects of competition may have substantial externalities throughout these networks (Brueckner & Spiller [1991], Zhang & Wei [1993]).

Using a similar approach to Brueckner & Spiller [1991], I provide in Chapter 2 a framework for analysing some aspects of intra-European, airline competition. The present chapter extends the precedent work in the following directions. First, dynamics are introduced to take strategic effects into account. Second, the model

allows for an explicit treatment of the most important air freedom rights governing international airline competition: Fifth/seventh freedom and cabotage freedom rights. In the airline's jargon the (fifth)seventh freedom traffic right would allow, e.g., Air France to serve the intra-European (Paris)-Frankfurt-Milan route, while the cabotage right would allow Air France to serve the domestic Milan-Rome route. Consequently, a cross-national open-entry policy is provided under these air freedom rights. Cabotage rights will be granted in April 1997 and correspond to **complete liberalisation** of the European airline industry<sup>1</sup>. Seventh freedom rights correspond to the present phase of liberalisation, which I call **partial liberalisation**.

Unlike the developments following the U.S. airline deregulation in October 1978, recent developments in the European airline industry suggest that European airlines made little use of their new entry opportunities provided by partial liberalisation. As I show later in the text, this lack of entry is acknowledged by leading airline specialists as well as by the Association of European Airlines [AEA]. Although there may be several reasons why European flag-carriers did not fully exploit the new entry opportunities (economic downturn, lack of demand, etc.), I suspect that strategic interactions arise when airlines repeatedly face each other in different markets within a network. When Air France makes use of its seventh freedom right on the Frankfurt-Milan route, Lufthansa and Alitalia's market shares are likely to be affected by Air France's entry. Since Air France operates simultaneously the Paris-Milan and Paris-Frankfurt routes, as a result of the past bilateral agreements, the opportunity for its rivals to retaliate in these markets is large: Lufthansa and Alitalia could retaliate in two of Air France's markets using their seventh freedom rights. As a result, Air France may simply be better off not serving the Frankfurt-Milan market. A similar reasoning may be applied when Air France makes use of its cabotage rights, say on the Milan-Rome route. This example illustrates the rationale of this chapter. To be more explicit, I want to investigate under which conditions a "mutual forbearance" equilibrium can be sustained in the case of partial liberalisation and complete liberalisation of the European airline industry. In that respect, this work is an attempt to provide a theoretical analysis of the Third Package. Consequently, the issues addressed in this work could be relevant to EU airline competition policy.

The sketch of the model is as follows. Three hub-and-spoke [H&S] flag-carriers meet each other repeatedly in several geographical markets. Depending on the regulatory regime (partial or complete liberalisation), each airline has either the option to stick to past bilateral agreements, obtaining duopoly profits on the intra-European markets, or the option to enter into new markets and to expand its operations<sup>2</sup>. Each flag-carrier has to compare its gains from sticking to past

---

<sup>1</sup>Complete liberalisation would make the European airline industry legally equivalent to the deregulated domestic U.S. airline industry.

<sup>2</sup>Of course, under complete liberalisation the opportunity to operate a larger network is more important than under partial liberalisation.



bilateral agreements (tacit collusion) and its gains from deviating given that, in case of deviation, a trigger strategy is applied. In solving the games, one for each regulatory regime, we will be looking under which conditions a subgame perfect equilibrium through the trigger strategy can be formed. The fact that infinitely repeated games have many different equilibrium outcomes is known as the Folk Theorem. In what follows, I compare the *most* collusive equilibrium outcomes that can be sustained under each regulatory regime. Therefore, I will define, for each regime, a range of discount factors over which noncooperative collusive outcomes can be sustained by the trigger strategy. The regulatory regime which has the *lower minimum* discount factor will, *ceteris paribus*, more likely be able to support the “mutual forbearance” equilibrium described above.

The results of this chapter are mainly driven by the network H&S structure and by the fixed costs associated with entry. I assume that fixed costs associated with entry into a rival’s domestic leg are larger than those associated with entry into an intra-European leg. In the latter leg the flag-carrier is already present in both end points, while in the former the flag-carrier must add a new station to its network. For sufficiently low fixed costs, complete liberalisation provides, in equilibrium, less opportunity to sustain collusion. In other words, when fixed costs are low, flag-carriers are more likely to sustain noncooperative collusive outcomes under partial liberalisation of the European airline industry. When fixed costs are nil, the range of discount factor over which flag-carriers can sustain collusive equilibria is *always* larger under partial liberalisation. Therefore, a “mutual forbearance” equilibrium is more likely to occur when fixed costs are high and/or under partial liberalisation. Some interesting policy implications could be inferred from these results. Moreover, the model provides an interesting relationship between the size of the network and the ease of sustaining collusion: For large domestic networks and large fixed costs, collusive outcomes are easier to sustain in equilibrium.

This chapter is organised as follows. Section 3.2 and the empirical analysis of Chapter 1 are the factual support of the model. Section 3.2.1 analyses airlines’ reactions to the new regulatory environment and relates the episodes of entry. Empirical evidence of strategic interactions in the airline industry is succinctly presented in Section 3.2.2. Then, Section 3.3 introduces the model. The assumptions are discussed in Section 3.3.1 with a particular focus on the description of the H&S network structure. Section 3.3.2 proposes the specifications for the demand and cost functions. The main results of the chapter are presented in Section 3.4. Section 3.4.1 and Section 3.4.2 deals with partial liberalisation and complete liberalisation, while Section 3.4.3 illustrates the results with a numerical example. Section 3.5 concludes.

## 3.2 Lack of Entry in Intra-EU Airline Markets

### 3.2.1 Reactions to the New Regulatory Environment

Although the introduction of the Third Package dates back 30 months, it is too early to assess exactly what effects these new measures will have on the industry. However, factual evidence of entry into new markets should provide some insights into the extent to which European airlines have exploited the new opportunities of market access (fifth/seventh freedom and eighth freedom or cabotage rights)<sup>3</sup>. To this end, I first report the comments of some leading experts on the industry. Then, I provide a brief empirical evidence of the episodes of entry.

The Association of European Airlines [AEA] publishes a Yearbook which describes the current trends in the industry. Actually, it is very instructive to report the AEA's point of view on the lack of entry issue. According to the AEA 1993 Yearbook, new opportunities of entry have appeared only occasionally. In fact, the AEA reported that:

*... "Initial reaction to the new opportunities has been properly cautious, as airlines test out the potential. Some new fifth freedom sectors have been added, as extensions of existing turnaround service. New cabotage city-pairs are generally on multi-stop routes already operated, but until now without the opportunity to market the local sector. Plans so far announced for seventh freedom operations concern BA's redesignation of some services of associates TAT [and Deutsche BA], and some purely leisure routes."*

It could be argued that the lack of initial reaction is due to the necessary lag for launching new air services. Consequently, it would be more appropriate to consider the episodes of entry some 18 months after the introduction of the new regulatory regime. It is striking to notice how the comments in the 1994 issue of the AEA Yearbook are similar to those made the previous year. The 1994 issue again stresses the lack of entry into new routes in accordance with the Third Package. In a somewhat tactful tone, the AEA relates, that:

*... "In Europe, opportunities in the Third Package were tempered by economic reality, and few routes were introduced which would not normally have been authorised under the old regulatory regime... The most remarkable freedom in the Package -the 7th freedom-remained virtually unused,*

---

<sup>3</sup>Remember that **seventh freedom** is defined as the ability of carrying passengers between two countries by an airline of a third on a route outside its home country (for example, Air France serving the Frankfurt-Milan route). If this route has as origin/destination its home country, then we have the so-called **fifth freedom** right (for example, Air France serving the Paris-Frankfurt-Milan route). **Eighth freedom or cabotage** is defined as the ability of carrying passengers within a country by an airline of another country (for example, Air France serving the Milan-Rome route). Notice that most of the time, cabotage routes are combined with an origin/destination in their home country, but not necessarily.

*with the exception of some British Airways services from Berlin and Paris using aircraft of associates Deutsche BA and TAT... A few cabotage routes were opened... Similarly, some fifth freedom sectors were added to existing turnaround services, again with the new opportunities permitting more flexible solutions to serving less dense markets. However, a number of Third Package-linked routes which opened early in 1993 were discontinued by year-end, demonstrating that opportunities to find profitable niches in an already well-served marketplace are still very limited."*

Similar comments are reported by Geoffrey H. Lipman, one of the leading experts of the European airline industry and President of the World Travel and Tourism Council [WTTC], who observed with insight that<sup>4</sup>:

*... "The EU's open-skies policy, which freed carriers to pick their own routes and set their own fares, hasn't been widely used because it requires a competitive market environment. With traffic on most European routes still dominated by duopolies of national flag-carriers, they tend to operate in the old way. There's no incentive for them to try new products or new prices."*

It is interesting to mention that, very recently, the AEA 1995 Yearbook reports that "two years later on, the picture in Europe does not appear to have changed dramatically".

In order to give more insight into the lack of entry issue, I provide a brief empirical evidence of the episodes of entry. It is beyond the scope of this work to provide a detailed analysis of each episode of entry. My aim is rather to illustrate the number of routes operated within the EEA in accordance with the Third Package as they were observed in August 1994. This is provided by Table 3.1 (see page 90). Table 3.1 classifies the routes according to whether they are operated under fifth, seventh or eighth (cabotage) freedom rights which are key for intra-EU (and international) air transport competition. Moreover, since new entries have been followed by numerous exits, Table 3.1 records the entry and exit pattern.

..

---

<sup>4</sup>International Herald Tribune, 1 February 1994.

Table 3.1: AEA Routes Operated within the EEA in Accordance with the Third Package.

FIFTH FREEDOM	SEVENTH FREEDOM	CABOTAGE
Introduced in 1993 and since discontinued	Introduced in 1993 and since discontinued	Introduced in 1993 and since discontinued
(AF) Paris-Thessaloniki-Larnaca* (AF) Nice-Copenhagen-Stockholm (AZ) Milan-Copenhagen-Stockholm (LG) Luxemburg-Metz-Palermo (LG) Luxemburg-Metz-Stansed* (LG) Luxemburg-Saarbrücken-Palma* (IB) Madrid-Amsterdam-Copenhagen (IB) Madrid-Amsterdam-Stockholm (IB) Madrid-Amsterdam-Gothenburg (IB) Madrid-Amsterdam-Helsinki (IB) Barcelona-Amsterdam-Gothenburg (IB) Barcelona-Amsterdam-Copenhagen (IB) Barcelona-Amsterdam-Stockholm (TP) Lisbon-Nice-Stuttgart* (TP) Lisbon-Rome-Athens	(LG) Metz-Málaga (LG) Mulhouse-Palma	(AF)** Lyon-Munich-Nuremberg* (AF) Paris-Naples-Palermo* (AF) Paris-Naples-Bari* (AF) Paris-Thessaloniki-Athens* (AF) Paris-Leipzig-Dresden* (AF)** Paris-Innsbruck-Linz* (AF)** Paris-Salzburg-Vienna* (LH) Munich-Rome-Bari* (LH) Frankfurt-Genoa-Naples* (LH) Frankfurt-Rome-Bari (SK) Copenhagen-Hamburg-Leipzig (TP) Lisbon-Toulouse-Bordeaux-Lisbon (TP) Lisbon-Nice-Marseille-Lisbon**
Introduced in 1993 and still operated	Introduced in 1993 and still operated	Introduced in 1993 and still operated
(AF) Lyon-Toulouse-Madrid-Lisbon* (AZ) Milan-Frankfurt-Oslo (AZ) Milan-Brussels-Dublin (AY) Helsinki-Stockholm-Manchester (AY) Helsinki-Stockholm-Stuttgart (AY) Helsinki-Stockholm-Berlin (AY) Helsinki-Stockholm-Oslo (AY) Helsinki-Gothenburg-Amsterdam* (AY) Helsinki-Amsterdam-Madrid (AY) Helsinki-Düsseldorf-Barcelona (AY) Helsinki-Athens-Istanbul-Helsinki** (AY) Helsinki-Oslo-Gothenburg-Helsinki* (BA) London-Turin-Thessaloniki (EI) Dublin-Manchester-Copenhagen* (EI) Dublin-Manchester-Zurich (KL) Amsterdam-Gothenburg-Helsinki* (KL) Amsterdam-Brussels-Cardiff* (LG) Luxembourg-Strasbourg-Vienna* (LH) Frankfurt-Copenhagen-Oslo (OA) Athens-Copenhagen-Stockholm (OA) Athens-Naples-Marseille (OA) Thessaloniki-Copenhagen-Stockholm (OS)** Vienna-Copenhagen-Gothenburg* (SK) Copenhagen-Manchester-Dublin* (SK) Copenhagen-Brussels-Lyon (SK) Copenhagen-Stuttgart-Thessaloniki (SR)** Zurich-Copenhagen-Stockholm* (SR) Zurich-Gothenburg-Helsinki (SR)** Zurich-Strasbourg-Luxembourg (TP) Lisbon-Copenhagen-Oslo (TP) Lisbon-Copenhagen-Stockholm	(BA)** Paris-Copenhagen (BA)** Paris-Munich (LG) Metz-Palma (SN) Venice-Barcelona	(AF)** Paris-Bern-Lugano* (AF) Paris-Edinburgh-Glasgow* (AZ) Rome-Barcelona-Valencia (AZ) Milan-Porto-Lisbon* (AZ) Milan-Barcelona-Málaga (AY) Helsinki-Hamburg-Stuttgart* (AY) Helsinki-Zurich-Geneva* (AY) Helsinki-Hamburg-Berlin-Helsinki (BA) London-Hannover-Leipzig* (KL) Amsterdam-Porto-Lisbon* (KL) Amsterdam-Guernsey-Jersey (KL)** Amsterdam-Salzburg-Innsbruck (LG) Luxembourg-Saarbrücken-Munich (LH) Düsseldorf-Guernsey-Jersey (LH) Frankfurt-Guernsey-Jersey (LH) Hamburg-Guernsey-Jersey (OA) Athens-Madrid-Barcelona* (SN) Brussels-Edinburgh-Glasgow (SR)** Basle-Leipzig-Dresden* (SR)** Zurich-Jersey-Guernsey* (TP) Faro-Zurich-Geneva-Faro** (TP) Porto-Zurich-Geneva-Porto** (TP) Lisbon-Milan-Rome-Lisbon*

FIFTH FREEDOM	SEVENTH FREEDOM	CABOTAGE
Introduced in 1994	Introduced in 1994	Introduced in 1994
(KL) Amsterdam-Luxembourg-Strasbourg* (LG) Luxembourg-Nice-Rome-Luxembourg+ (SN) Brussels-Lyon-Bologna	(BA)** Stockholm-Nice (BA)** Rome-Nice (BA)** Brussels-Nice (BA)** Berlin-Stockholm (BA)** Berlin-Oslo (BA)** Munich-Madrid (BA)** Paris-Stockholm (BA)** Paris-Frankfurt (BA)** Paris-Dresden (BA)** Stuttgart-Lyon (BA)** Stuttgart-Marseille (BA)** Stuttgart-Venice (LG) Mulhouse-Malaga	(SK) Copenhagen-Barcelona-Madrid (TP) Lisbon-Lyon-Nice-Lisbon+ (TP) Lisbon-Berlin-Hamburg-Lisbon+

*Source:* AEA Yearbook 1994, ABC World Airways Guide, various issues.

*Notes:* \* Operated before January 1993. \*\* Jointly operated and/or code sharing arrangements. + Fifth freedom or cabotage rights one way only.

Table 3.1 needs numerous comments. First, except for Finnair (AY), Iberia (IB) and, to a lesser extent, Alitalia (AZ), Portuguese TAP (TP) and Greek Olympic Airways (OA), European flag-carriers do not operate many new fifth freedom routes. It should be noticed that flag-carriers which have entered several fifth freedom routes are typically located on the North or the South of the continent. Consequently, these new fifth freedom routes are more likely to be extensions of an existing turnaround service<sup>5</sup>. Second, the real innovative seventh freedom routes are mainly operated by British Airways (BA) through its associates<sup>6</sup> TAT and Deutsche BA, by Luxair (LG) and by the Belgian Sabena (SN) on the Venice-Barcelona route. Third, many fifth freedom and cabotage routes were already operated before January 1993 (routes operated before 1993 are indexed by \*). Moreover, cabotage routes are always combined with a route to the home country, reflecting one of the principal restriction on cabotage rights. Finally, a significant number of routes introduced in 1993 were withdrawn from the European networks. The results of Table 3.1 are summarised in the following way, once one excludes the routes which were already operated before January 1993.

	Introduced in 1993 and since discontinued	Introduced in 1993 and still operated	Introduced in 1994
Fifth Freedom	11	20	2
Seventh Freedom	2	4	13
Cabotage	2	9	3

For the whole European airline industry a total of 51 routes within the European Economic Area have been introduced and are still operated. This figure has

<sup>5</sup>For example, on the Copenhagen-Stockholm route.

<sup>6</sup>British Airways equity shares are 49.9% and 49%, respectively.

to be contrasted with the several hundred of possible routes which could be operated in accordance with the new market access rules provided by the Third Package (approximately 1'000 routes are operated within the EEA). This result suggests that the market access "big bang" that some experts have foreseen, clearly did not occur. In particular, one could be disappointed by the few new seventh freedom routes entered, since these are the more innovative and less restricted routes granted under the Third Package. Although the conditions differ, it is interesting to contrast this result with the reaction of U.S. airlines following the U.S. airline deregulation in October 1978. Studying the contestability of U.S. airline markets during the transition to deregulation, Bailey & Panzar [1981] provide a measure of the speed and pervasiveness of new awards which occurred after October 1978. According to these authors, there were 3,189 nonstop route rights granted in the five-month period immediately following deregulation, with another 7,142 route awards pending on February 1979. To put these numbers in perspective, they reported that as of January 1, 1980, there were 2,449 route segments actually flown in the domestic U.S. market by all certificated carriers. Accordingly, even if not every new route award translated into actual entry, many new markets were entered during the first few months after the U.S. deregulation. According to Bailey & Panzar [1981], a total of 449 nonstop routes were added during the period between July 1, 1978, and July 1, 1979. However, the reorganisation of U.S. airlines' method of delivery in favour of H&S network led to numerous deletions of nonstop routes. According to these authors, 332 routes were actually deleted. In summary, Bailey & Panzar's results tend to suggest that with the removal of regulatory barriers to entry, U.S. carriers reacted quite intensively to new market access opportunities.

Although there may be several reasons why European flag-carriers did not fully exploit the new entry opportunities (economic downturn, lack of demand or natural monopoly in thin markets, etc.) I suspect that one good reason could stem from the strategic interactions that arise when airlines face repeatedly each other in different markets. This assumption has found recent empirical support in the conduct of U.S. airlines. The next section summarises the main findings on strategic interactions in the U.S. airline industry.

### **3.2.2 Strategic Interactions in the Airline Industry**

It has been recognised that strategic interactions are likely to arise when oligopolists operate in several markets. Khan [1950] and Edwards [1955] first expressed the idea that when firms compete simultaneously in several different markets, each may come to specialise in some subset of these markets, and such specialisation may help firms maintain high (supracompetitive) prices. Alternatively, firms may recognise their mutual interests and interdependence throughout the markets where they operate and, as a consequence, be more cautious about com-

peting vigorously for fear of retaliation<sup>7</sup>. However, it has also been argued that the informational and monitoring requirements for reaching and sustaining collusive arrangements in any one market may increase significantly when firms face each other in several different markets (Stigler [1964]). In that case, multi-market contact may hinder oligopolistic coordination. If both arguments are valid, then only empirical evidence can ultimately assess whether multi-market contact improves or hinders the ability of oligopolists to sustain collusive noncooperative agreements.

Evans & Kessides [1993,1994] and Barla [1992] have collected such empirical evidence on the (U.S.) airline industry. This industry is a perfect candidate for an application of the multi-market contact argument, since airlines repeatedly meet and compete with each other in several oligopoly markets. Evans & Kessides [1994] first formulated the idea that multi-market contact could play a significant role in airlines' pricing behaviour<sup>8</sup>. In fact, in an attempt to measure the effects of the U.S. airline industry's structure on performance, these authors suggest that multi-market contact can potentially affect prices. More precisely, they argued that [p.464,1993]:

*... "The observed increase in the number of inter-route contacts could potentially have important implications for market performance if the multiplicity of contacts between firms helps to blunt competition. The formal hypothesis is typically called multi-market contact or mutual forbearance. The basic premise of the hypothesis is that firm interdependence arising from external contacts increases the ability and incentive for firms in any single market to attain and maintain cooperative arrangements. More specifically, firms that meet as competitors in many markets may be less likely to exploit their competitive advantage in any particular market for fear of retaliation in some or all of their jointly contested markets."*

Inter-market linkages increased substantially as U.S. airlines adopted the H&S structure as method of delivery and with the merger wave observed in the mid' 80s. Not surprisingly, their results indicate that in routes served by airlines with extensive inter-route contacts, fares are significantly higher, suggesting that multi-market or multi-point contact improves the ability of U.S. airlines to sustain noncooperative collusive outcomes. Barla's paper [1992] analyses two aspects of multi-market contact in the U.S. airline industry which are 1) the transfer of market power across markets (firms can use the slack that may exists in the enforcement of the collusive outcome in one market and transfer it in another one, see Bernheim & Whinston [1990]) and 2) the mutual threat strategy (retaliation in a

<sup>7</sup>Recently, Bernheim & Whinston [1990] provided a formal treatment in which they isolated conditions under which multi-market contact facilitates collusion among oligopolists. In particular they show that, with perfect monitoring, noncooperative collusive outcomes are more likely to arise under "certain natural conditions" such as markets differing in the number of firms, firms differing in costs and/or technology allowing for increasing returns.

<sup>8</sup>Kim & Singal [1993] discuss the role of multi-market contact in the context of a merger.

multi-market framework may occur in (all) other markets). The empirical results suggest that both features play an important role in the conduct and performance of the U.S. airline industry. In particular, both features are likely to increase airlines' market power.

In Europe, unfortunately, the lack of data substantially restricts the opportunity to conduct such an empirical research. However, it is reasonable to think that the long-standing relations which European flag-carriers have developed during the pre-liberalisation regime, have contributed to the recognition of flag-carriers' mutual interests. In fact, it is admitted that before the liberalisation phase, European flag-carriers used to overtly cooperate on many markets or routes and this, undoubtedly, resulted in knowing each other better. In addition, very powerful and well-organised trade associations such as IATA<sup>9</sup> or AEA certainly facilitate "contacts" between European flag-carriers and contribute to lowering the informational and monitoring costs required for the maintenance of the "collusive" outcomes suggested by the multi-market contact argument<sup>10</sup>.

### 3.3 The Model

#### 3.3.1 Assumptions and Model Set-up

As stressed throughout Chapter 1 and in the precedent section, the European airline industry provides several interesting features. First, European city-pair markets are typically operated by few oligopolist flag-carriers. Second, European flag-carriers are likely to recognise their mutual interests and interdependence throughout the markets (linked networks) where they operate because of their long-standing relations in the business. Third, because of heavy past regulations and/or geographical characteristics of European countries, most European flag-carriers operate a H&S network centred in one major (hub) airport. Then, given these features, an interesting question arises: Under which circumstances does a flag-carrier prefer to guarantee itself "collusive" noncooperative duopoly profits on the intra-European markets rather than to meet more competitors on more intra-European routes (i.e., to make use of the new air freedom rights provided by the Third Package) ? The aim of the present chapter is to address this question. To this end, I use a game theoretic model which allows for an explicit treatment of the strategic effects arising among oligopolist flag-carriers. In addition, the model takes the nature of an airline H&S network and the European regulatory environment into account. Two scenarios are discussed: **partial** and **complete** liberalisation of the European industry. Complete liberalisation is supposed to be in force as of April 1997, when complete cabotage freedom will be granted.

---

<sup>9</sup>International Air Transport Association.

<sup>10</sup>As suggested by Rees [1994], the share of a common Computer Reservation System [CRS] can also contribute to lowering these costs. CRS mainly used in Europe are GALILEO and AMADEUS. Both systems are shared and operated by several European flag-carriers.



The main (static) assumptions of the model are presented first with a particular focus on the description of the H&S network structure (ASSUMPTIONS I). The (dynamic) assumptions and description of the games follow (ASSUMPTIONS II).

### ASSUMPTIONS I:

- Three identical flag-carriers (airlines),  $f=A,B,C$ , operate scheduled air passenger services on a given H&S network<sup>11</sup>. Note that one must consider at least three flag-carriers to provide the minimum framework for analysing seventh freedom and cabotage airline competition. Flag-carriers are thought of as single-product firms that operate in a number of distinct geographic markets (multi-market firms). For computational convenience, I assume symmetric flag-carriers, i.e., using the same technology and operating symmetric networks. In particular, each flag-carrier operates aircraft on legs,  $l$ , of equal distance.
- Markets are not identical. This assumption leaves room for the provisions granted by the Third Package of regulatory rules, which provides flag-carriers with the ability to maintain, until April 1997, some monopoly markets (usually domestic markets) and to compete with incumbent flag-carriers in other markets (usually duopoly intra-European markets).
- As a result of government regulation or some other insurmountable barrier to entry (high fixed and/or sunk costs), additional entry throughout the network by non-incumbent airlines is ruled out<sup>12</sup>.
- Flag-carriers provide a *homogeneous* service. Quantities are airlines' strategy variable. I interpret a choice of quantity as that of a scale of operation or capacity<sup>13</sup>. It is assumed that the scale of operation is quickly and easily adjusted<sup>14</sup>. This occurs because of the existence of an active and competitive

---

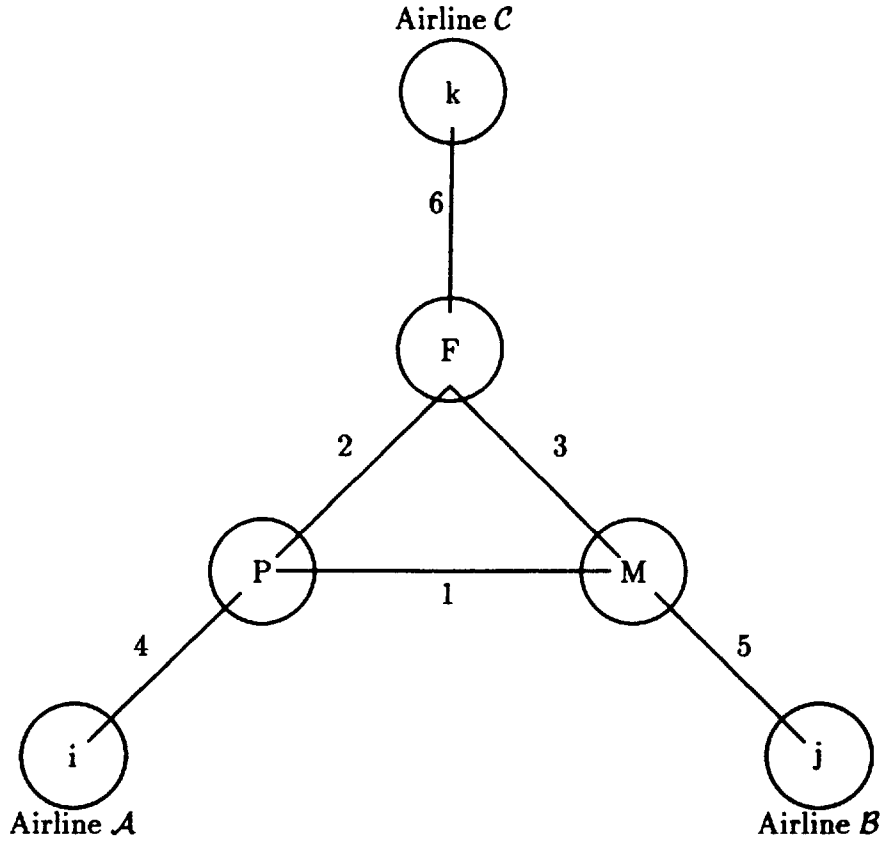
<sup>11</sup>It is therefore implicitly assumed that it is profit maximising to organise production on a H&S network.

<sup>12</sup>Borenstein [1992] argues that, although there are charter companies or regional airlines that may be able to enter into some markets, "the most likely potential entrants on any of the major European city-pair markets are scheduled carriers that currently serve both end points of the market from their own base city."

<sup>13</sup>I shall refer to Kreps & Scheinkman [1983] in order to justify this quantity game. Airline competition can be modelled as a two-stage process, where airlines set capacity in the first stage (long run investment in capacity) and compete in price in the second stage. Kreps & Scheinkman [1983] show that when the capacities chosen in the first stage correspond to the Cournot output levels, in the second stage firms name the Cournot price. Therefore, even if airlines seem to compete in price, Kreps & Scheinkman's results provide support for the use of a quantity game. Notice that Cournot behaviour in the airline industry has found empirical support in the literature, see for example Brander & Zhang [1990,1993].

<sup>14</sup>In fact, in a dynamic version of the Kreps & Scheinkman's paper, Benoit & Krishna [1987] have shown that when duopolists have the ability to continually adjust their capacity levels or can adjust their capacity levels quickly, they may be able to earn noncooperative collusive profits without building excess capacity.

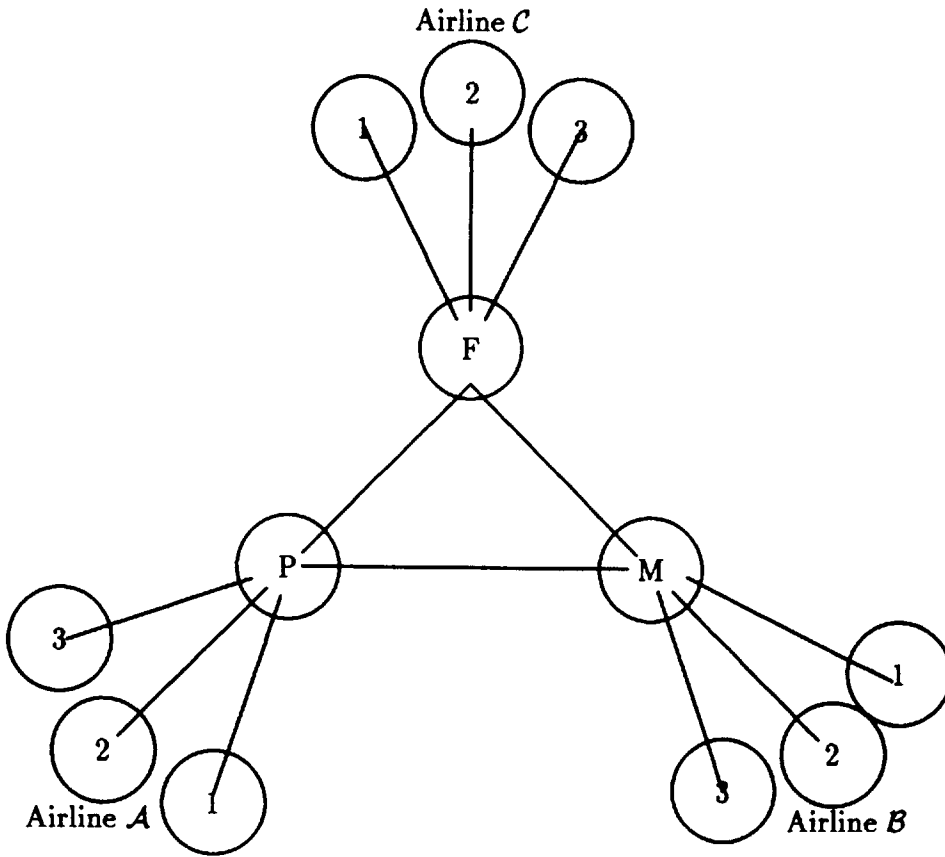
Figure 3.1: Three Linked H&S Networks with One Domestic Leg ( $N = 1$ )



rental market for aircraft.

The simplest H&S network involving three flag-carriers is represented in Figure 3.1. For historical reasons, Airline *A* operates aircraft on legs  $l = 1, 2, 4$  which connect cities  $i, P, M$ , and  $F$ .  $P$  is the central point (hub) of Airline *A*'s network (generally country *A*'s capital). Leg  $l = 4$  connects cities  $i$  and  $P$  and is a purely domestic leg, i.e., cannot be operated by another incumbent flag-carrier. The legs  $l = 1, 2$  are the intra-European legs and on these legs Airline *A* competes simultaneously with Airline *B* and Airline *C*. Airline *B* operates aircraft on legs  $l = 1, 3, 5$ , connecting cities  $j, M, P$ , and  $F$ . Airline *B*'s domestic leg,  $l = 5$ , connects cities  $j$  and  $M$ . On the intra-European leg  $l = 3$ , Airline *B* competes with Airline *C*. Finally, Airline *C* operates aircraft on legs  $l = 2, 3, 6$ , connecting the cities  $k, F, P$  and  $M$ . Airline *C*'s domestic leg,  $l = 6$ , connects cities  $k$  and  $F$ . In this simple symmetric network, each airline is in contact with another competitor on one intra-European leg (or two points). Airline *A* and Airline *B* are in contact on leg  $l = 1$ , while Airline *A* and Airline *C* are in contact on leg  $l = 2$ . Airline *B* and Airline *C* are in contact on leg  $l = 3$ .

Figure 3.2: Three Linked H&S Networks with Three Domestic Legs ( $N = 3$ )



Therefore,

- Intra-European legs,  $l = 1, 2, 3$ , directly connect hub airports,
- Domestic legs,  $l = 4, 5, 6$ , connect “peripheral” cities ( $i, j$  and  $k$ , respectively) to a hub airport ( $P, M$  and  $F$ , respectively) and,
- Each “peripheral” city is connected to another country with a one stop service at least.

Figure 3.1 corresponds to a very simple H&S network. An interesting generalisation of Figure 3.1 is to consider a H&S network with  $N$  different domestic legs. Figure 3.2, for example, corresponds to the case where each flag-carrier operates three monopoly (i.e.,  $i, j, k = 1, 2, 3$ ) and two intra-European legs. Accordingly, with  $N$  domestic legs ( $i, j, k = 1, \dots, N$ ), each flag-carrier would operate aircraft on  $L = N + 2$  legs. From now on, I consider this general set-up.

## ASSUMPTIONS II:

Repeated oligopolistic competition requires some additional assumptions.

- We assume that flag-carriers,  $f=A,B,C$ , operate in discrete time with an infinite<sup>15</sup> horizon and a common discount factor,  $\delta = 1/(1+r)$ , where  $r$  is the constant interest rate<sup>16</sup>. Furthermore, complete information, in particular full knowledge of each other's profit functions, and perfect monitoring are assumed<sup>17</sup>.
- A trigger strategy described by Friedman [1971] is used. The motives for choosing a trigger strategy are that (a) it is simple to characterise, (b) it is easier to implement than any other more sophisticated strategy<sup>18</sup> and (c) it seems reasonable for the airline industry. Flag-carriers face repeated mutual entry threats throughout the network according to the regulatory regime. Each flag-carrier  $f$  has an action set  $A_f = \{\text{to enter, not to enter}\}$  and a pure strategy set  $S_f = \{\text{to enter if a deviation has been observed, to stick to the bilateral agreements otherwise}\}$ <sup>19</sup>. Airlines move simultaneously<sup>20</sup>. The stage game (one shot-game) of the repeated games is equal under both regulatory regimes and is the following: In period  $t$ , Airline  $f$  sticks to the existing bilateral agreements so long as no entry into Airline  $f$ 's markets has been observed in the previous period. If an entry is observed in period  $t$ , Airline  $f$  retaliates in the following period by entering into its rival incumbents' markets and producing at the Cournot-Nash outcome for the remainder of the game. Irreversible and permanent entry together with reversion to the Cournot-Nash outcome is a particularly "grim" trigger strategy. Note that irreversible entry rules out strategies such as hit-and-run behaviour. The solution concept used is that of subgame perfect equilibrium<sup>21</sup> and, given the symmetry (and stationarity) of the model, I look for optimal stationary symmetric-payoff equilibria.

## GAME I:

In a first repeated game, I consider **partial liberalisation** of the European airline industry so that cabotage rights are not granted to flag-carriers. Given the net-

---

<sup>15</sup>The horizon need not require to be infinite as long as firms always assign positive probability to the game continuing (see, for e.g., Fudenberg & Tirole [1991]).

<sup>16</sup>A  $\delta$  close to 1 represents low impatience, since the opportunity cost is low. Put differently, the rate of time preference for profit is low.

<sup>17</sup>The so-called "facilitating devices" which are, to a certain extent, provided by trade associations such as IATA or AEA lessen these monitoring and informational costs.

<sup>18</sup>Abreu [1988] has shown that the trigger strategy designed by Friedman in general uses a non-optimal punishment.

<sup>19</sup>Given the demand specification (3.3), flag-carrier  $f$ 's pure strategies are quantities  $s_f \in [0, \alpha/\beta]$ , for each market operated.

<sup>20</sup>Consequently, this is a game of complete but imperfect information.

<sup>21</sup>According to Bernheim & Whinston [p.2,1990]: "the set of subgame perfect equilibria may also be viewed as the set of credible nonbinding agreements available to firms, since any element of this set specifies actions that are in each firm's individual self-interest at all times".

work of Figure 3.2, each flag-carrier has the option to enter on one new seventh freedom leg and to compete there with the other two incumbent flag-carriers. As an example, consider Airline  $\mathcal{A}$ 's strategy in the framework of Figure 3.2. Airline  $\mathcal{A}$  deviates<sup>22</sup> in period  $t$  from previous bilateral agreements by entering the  $FM$  market (seventh freedom leg), which is operated by incumbent Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  as a result of past bilateral agreements. Following the entry, Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  retaliate in period  $t + 1$  by entering on the  $PF$  and  $PM$  markets. Consequently, the additional profit which arises following Airline  $\mathcal{A}$ 's deviation should be compared with the losses incurred in the following periods when, as a result of (rational) retaliation, each flag-carrier operates aircraft on all intra-European legs. Notice that, since airlines operate on many markets, costs and benefits following a deviation do not raise proportionally. In fact, following the defection in one market ( $FM$ ), Airline  $\mathcal{A}$  is simultaneously punished in two markets ( $PF$  and  $PM$ ). Given partial liberalisation, sticking to the previous bilateral agreements, and producing the corresponding collusive output in each period, is a subgame perfect equilibrium through trigger strategies in the infinite horizon game, if Airline  $\mathcal{A}$ 's incentive constraint satisfies:

$$\pi_{\mathcal{A}}^{dev} + \sum_{t=1}^{\infty} \delta^t \pi_{\mathcal{A}}^{pun} \leq \sum_{t=0}^{\infty} \delta^t \pi_{\mathcal{A}}^{col}, \quad (3.1)$$

or, in a more informative way,

$$\pi_{\mathcal{A}}^{dev} - \pi_{\mathcal{A}}^{col} \leq \frac{\pi_{\mathcal{A}}^{col} - \pi_{\mathcal{A}}^{pun}}{r},$$

where  $\pi_{\mathcal{A}}^{col}$  is Airline  $\mathcal{A}$ 's per period profit without entry,  $\pi_{\mathcal{A}}^{dev}$  is Airline  $\mathcal{A}$ 's per period profit following its entry and  $\pi_{\mathcal{A}}^{pun}$  is Airline  $\mathcal{A}$ 's per period profit from retaliation.

## GAME II:

In a second game, I assume a **complete liberalisation** of the European airline industry so that cabotage rights are now granted. Now, each flag-carrier has the option to enter on one seventh freedom leg and  $2N$  domestic legs. It is assumed that, since a flag-carrier expects to be punished in all markets (throughout its network), it will consider deviating in all markets, i.e., a harsher punishment structure is used. One might object to this simultaneous large scale entry on the grounds that a more gradual entry strategy is more plausible in the European airline industry. Clearly, this latter scenario should be considered as the competitive benchmark under complete liberalisation<sup>23</sup>. Notice that during the deviation period, Airline  $\mathcal{A}$  enjoys duopoly profits on the former (domestic) monopoly markets

<sup>22</sup>In deciding whether to deviate, Airline  $\mathcal{A}$  assigns probability zero to a rival deviating in the same period.

<sup>23</sup>Therefore, not only is it assumed that the scale of operation is easily adjusted, it is also assumed that flag-carriers operate without capacity constraint on airport landing slots. While it has been recognised that most flag-carriers bear aircraft excess capacity, airport landing slots may be an important issue in some busy European airports (see Borenstein [1992]). See also footnote 14.

operated by Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$ , while punishment implies that all markets in the network are operated by all flag-carriers. Given complete liberalisation, sticking to the previous bilateral agreements, and producing the corresponding collusive output in each period, is a subgame perfect equilibrium through trigger strategies in the infinite horizon game, if Airline  $\mathcal{A}$ 's incentive constraint satisfies:

$$\Pi_{\mathcal{A}}^{Dev} + \sum_{t=1}^{\infty} \delta^t \Pi_{\mathcal{A}}^{Pun} \leq \sum_{t=0}^{\infty} \delta^t \Pi_{\mathcal{A}}^{Col}, \quad (3.2)$$

where  $\Pi_{\mathcal{A}}^{Col}$  is Airline  $\mathcal{A}$ 's per period profit without entry,  $\Pi_{\mathcal{A}}^{Dev}$  is Airline  $\mathcal{A}$ 's per period profit following its entry and  $\Pi_{\mathcal{A}}^{Pun}$  is Airline  $\mathcal{A}$ 's per period profit from retaliation.

Since infinitely repeated games have many different equilibrium outcomes (the Folk Theorem<sup>24</sup>), in what follows I compare the most collusive equilibrium outcomes that can be sustained under (3.1) and (3.2). I therefore define, for each regulatory regime, a range of discount factors over which noncooperative collusive outcomes can be sustained by the trigger strategy. The regulatory regime which has the *lower minimum* discount factor is, *ceteris paribus*<sup>25</sup>, more able to support the “mutual forbearance” equilibrium described above. In order to derive useful results, the following specifications are adopted. These specifications borrow heavily from previous papers in transportation economics.

### 3.3.2 Specifications

The specifications are similar to those chosen in Chapter 2. In particular, assume that flag-carriers face a linear symmetric demand across city-pairs. The inverse demand function for round-trip travel in any given city-pair market  $xy$  is given by  $P(Q_{xy})$ , with  $Q_{xy}$  representing the number of round-trip passengers in the market  $xy$ . Note that  $Q_{xy}$  represents the number of passengers travelling from city  $x$  to city  $y$  and back, plus the number of passengers travelling from city  $y$  to city  $x$  and back. The demand for international services is limited in the sense that  $Q_{ij}^D = Q_{ik}^D = Q_{jk}^D = 0$ . Put differently, there is no demand between cross-border “peripheral” cities<sup>26</sup>. While gaining in simplicity<sup>27</sup>, the model captures the following feature: Most intra-European traffic flows stop at hub airports. This is particularly relevant for central EU countries, where capitals mostly attract

<sup>24</sup>Friedman [1991] provides the following definition (p.111): The Folk Theorem for repeated games states that any attainable payoff vector in a single-shot game can be the realised equilibrium payoff in each period of a repeated game if the payoff vector gives more to each player than does the lowest payoff to which the player could be forcibly held.

<sup>25</sup>For given characteristics of individual firms, set of output to be sustained and punishment strategy.

<sup>26</sup>Notice that the indexes  $i, j$ , and  $k$  are running over peripheral cities only.

<sup>27</sup>With  $n$  the number of cities, the total city-pairs would be  $n(n-1)/2$ . When  $n = 6$ , as Figure 3.1 suggests, we have potentially 15 different city-pairs. With the previous assumption, the model is reduced to 12 different city-pairs.

leisure and business travellers. In order to keep the model as simple as possible, I also assume that there is no demand between “peripheral” cities within the same country, i.e.,  $Q_{ii'}^D = Q_{kk'}^D = Q_{jj'}^D = 0$ , for all  $ii', kk', jj'$  <sup>28</sup>. In addition, because the change of carrier implies higher risks of missing a connection (often associated with the change of terminal in hub airports and/or the lack of flight coordination between carriers) or of losing baggage, a passenger originating his journey in  $i$  and willing to fly to city  $F$ , for example, is assumed to choose the same flag-carrier, i.e., Airline  $\mathcal{A}$ . These travellers’ preferences ensure that each airline is able to transport their connecting passengers on the intra-European leg. Airline  $\mathcal{A}$ , for example, carries all the  $Q_{iF}$  and  $Q_{iM}$  passengers. Similarly, Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  carries all the  $Q_{jP}$ ,  $Q_{jF}$  and  $Q_{kP}$ ,  $Q_{kF}$  travellers, respectively. More specifically, let the inverse demand function be:

$$P(Q_{xy}) = \alpha - \beta Q_{xy}, \quad \text{with } \alpha \text{ and } \beta > 0. \quad (3.3)$$

The intercept of the demand function in (3.3),  $\alpha$ , is identical for all city-pair markets  $xy$ . This is equivalent to assuming that the cities are similar in size. By eliminating differences in size between cities, this assumption allows us to highlight the effects of network and market structure on the (collusive) equilibria in two different liberalisation settings. Notice that the demand for travelling in the  $xy$  market does not depend neither upon prices in any of the other markets nor upon prices of substitute modes of transportation<sup>29</sup>.

The assumption of common distance of the legs of the network implies a common cost function,  $C_l(Q_l)$ , applying to each of the legs  $l$  in the network. This cost function gives the round-trip cost of carrying  $Q_l$  travellers on one leg. H&S networking implies that  $Q_l$  represent both local as well as connecting (i.e., with the same origin but with different destinations) passengers. On the leg connecting city  $i = 1$  to city  $P$  of Figure 3.2, for example, Airline  $\mathcal{A}$ ’s aircraft carry both local, i.e.,  $i = 1$  to  $P$  passengers, as well as connecting passengers. In this case, all traffic  $Q_l$  routing through this leg corresponds to  $Q_{iP} + Q_{iF} + Q_{iM}$ . Similarly, all traffic transported by Airline  $\mathcal{A}$ ’s aircraft on the intra-European leg  $PM$ , for example, is composed of the local  $PM$  traffic, as well as all the connecting traffic from the “peripheral” cities to  $M$ , i.e.,  $\sum_{i=1}^N Q_{iM}$ . The cost function applying to each of the legs  $l$  allows for increasing returns to density<sup>30</sup> stemming from hubbing operations. Consequently,  $C_l(Q_l)$  satisfies the following properties:  $C_l(Q_l) > 0$ ,  $C'_l(Q_l) > 0$  and  $C''_l(Q_l) \leq 0$ . Following Brueckner & Spiller [1991], a

<sup>28</sup>This is more likely to happen when distance between “peripheral” cities is short enough for passengers to prefer a different mode of transportation.

<sup>29</sup>The former assumption expresses the idea that customers who wish to travel from city  $x$  to  $y$  have no desire to travel anywhere else in the network, while the latter follows from the assumption of partial equilibrium analysis.

<sup>30</sup>Returns to density arise when an increase of the volume of transportation services **within a given network** is more important than the associated increase in costs. See Caves et al. [1984].

$$C = \sum_l^L C_l(Q_l) = \sum_l^L (\theta Q_l - \gamma Q_l^2), \quad (3.4)$$

where  $C$  is the additive cost function for each flag-carrier,  $Q_l$  is the traffic volume of the relevant city-pair markets routing through leg  $l$ ,  $L$  is the total number of legs operated by the relevant flag-carrier,  $\theta > 0$ ,  $\gamma \geq 0$  allowing for increasing returns to density with  $\theta/\gamma > Q_l$ . Constant returns to density imply  $\gamma = 0$ . It has been argued that constant returns to density are likely to appear once the minimum efficient traffic density level is reached (see Oum & Tretheway [1992]). Let us assume for the sake of simplicity that this efficient traffic density level is reached throughout the network, so that<sup>31</sup>  $\gamma = 0$ . Therefore, the marginal cost per leg is constant and equal to  $\theta$ .

In the H&S network suggested by Figure 3.2, an airline has the option to enter into two different types of legs: The intra-European leg or the purely domestic leg. From the cost point of view, entry into a leg where an airline already operates both end points from its own H&S airport should not be treated like entry into a leg where one (or both) of the end points is not operated, which arises when a flag-carrier enters into a rival's pure domestic leg (see Figure 3.2). In this latter case, the airline has to set ground facilities at the new station, advertise its service to consumers who are less likely to be aware of the existence of the new service, and so on, making entry comparatively more costly. Many authors, in particular Levine [1987], have stressed this feature of airline network economics. Consequently, entry is modelled in the following way: Fixed costs associated with entry into the intra-European leg are supposed to be nil, while they are equal to  $F$  when entry occurs into a domestic leg<sup>32</sup>. In a dynamic setting, fixed costs persist as long as production continues. Note that under this assumption, the model allows for economies of scope, which may arise for multi-market and/or multi-product firms<sup>33</sup>. Here, an increase of the network resulting from an entry into the intra-European leg, for a given density of traffic, is more important than the associated cost. Notice that this latter issue is not discussed in Brueckner & Spiller [1991], who emphasise the role of returns to density in airline networks.

<sup>31</sup>As noticed in Chapter 2, cost-based linkages across markets (costs complementarity) exist as long as  $\gamma \neq 0$ , which considerably complicates the analysis of the effects of network and markets structure on the (collusive) equilibria.

<sup>32</sup>It could be argued that sunk costs  $K$  are incurred when flag-carriers begin service on a new leg. Since  $K$  can be expressed as a fraction of  $F$  ( $K = sF$  with  $s \leq 1$ ), I assume for simplicity's sake that  $s = 1$ , so that  $K = F$ .

<sup>33</sup>The cost advantage of jointly providing a large number of diversified routes (city-pairs) as against specialising in the provision of a single route, which is the definition of economies of scope, is likely to be significant for an European incumbent flag-carrier with respect to a regional entrant airline. This could justify the absence of entry by non-incumbent flag-carriers (see ASSUMPTIONS I). For a general discussion of indivisibilities arising in the airline industry see Levine [1987].



## 3.4 Results

### 3.4.1 GAME I: Partial Liberalisation

Given the symmetry of the model, I focus on equilibria which yield symmetric payoffs to the three airlines. Let us concentrate on the Airline  $\mathcal{A}$ 's equilibrium values. Consider first the most collusive equilibrium outcome, i.e., when no entry is observed on the intra-European  $FM$  leg. In that case, once airlines collude with a staying-out strategy, each airline would be better off with setting the monopoly quantity (maximum level of collusion) in markets with contact, i.e.,  $FM$ ,  $PM$  and  $PF$ . This is a likely outcome if the flag-carriers can use pre-play communication to focus beliefs on the best self-enforcing (nonbinding) agreement.

Under the previous assumptions (in particular, no demand between domestic and foreign "peripheral" cities), Airline  $\mathcal{A}$ 's city-pair markets are:  $iP, iM, iF, PM$  and  $PF$ , with  $i = 1, \dots, N$ . Airline  $\mathcal{A}$ 's profit function,  $\pi_{\mathcal{A}}$ , can be expressed as

$$\begin{aligned}\pi_{\mathcal{A}} = & \sum_{i=1}^N P(Q_{iP})Q_{iP} + \sum_{i=1}^N P(Q_{iM})Q_{iM} + \sum_{i=1}^N P(Q_{iF})Q_{iF} \\ & + P(Q_{PM})q_{PM}^{\mathcal{A}} + P(Q_{PF})q_{PF}^{\mathcal{A}} - C_{l=pm}(q_{PM}^{\mathcal{A}} + \sum_{i=1}^N Q_{iM}) \\ & - C_{l=pf}(q_{PF}^{\mathcal{A}} + \sum_{i=1}^N Q_{iF}) - \sum_{i=1}^N C_{l=ip}(Q_{iP} + Q_{iF} + Q_{iM}),\end{aligned}$$

or

$$\begin{aligned}\pi_{\mathcal{A}} = & \sum_{i=1}^N (\alpha - \beta Q_{iP})Q_{iP} + \sum_{i=1}^N (\alpha - \beta Q_{iM})Q_{iM} + \sum_{i=1}^N (\alpha - \beta Q_{iF})Q_{iF} \\ & + (\alpha - \beta(q_{PM}^{\mathcal{A}} + q_{PM}^{\mathcal{B}}))q_{PM}^{\mathcal{A}} + (\alpha - \beta(q_{PF}^{\mathcal{A}} + q_{PF}^{\mathcal{C}}))q_{PF}^{\mathcal{A}} - \theta(q_{PM}^{\mathcal{A}} + \sum_{i=1}^N Q_{iM}) \\ & - \theta(q_{PF}^{\mathcal{A}} + \sum_{i=1}^N Q_{iF}) - \sum_{i=1}^N \theta(Q_{iP} + Q_{iF} + Q_{iM}),\end{aligned}\tag{3.5}$$

where  $Q_{PM} = q_{PM}^{\mathcal{A}} + q_{PM}^{\mathcal{B}}$  and  $Q_{PF} = q_{PF}^{\mathcal{A}} + q_{PF}^{\mathcal{C}}$ . From (3.5), it can be observed that Airline  $\mathcal{A}$ 's revenues are generated from its  $3N + 2$  markets, while its costs correspond to aircraft flown on  $L = N + 2$  legs. From our assumptions, it appears that both  $PM$  and  $PF$  markets are simultaneously operated by Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$ . Therefore, Airline  $\mathcal{A}$  serves  $3N$  monopoly markets and two duopoly markets. In these latter markets, joint profit maximisation is assumed. Assuming interior solutions to the maximisation of (3.5), the solution of Airline  $\mathcal{A}$ 's problem implies the following  $3N + 2$  first order conditions:

$$\frac{\partial \pi_{\mathcal{A}}}{\partial Q_{iP}} = \alpha - 2\beta Q_{iP} - \theta = 0 \quad \text{for } i = 1, \dots, N \tag{3.6}$$

$$\frac{\partial \pi_{\mathcal{A}}}{\partial Q_{iM}} = \alpha - 2\beta Q_{iM} - 2\theta = 0 \quad \text{for } i = 1, \dots, N \quad (3.7)$$

$$\frac{\partial \pi_{\mathcal{A}}}{\partial Q_{iF}} = \alpha - 2\beta Q_{iF} - 2\theta = 0 \quad \text{for } i = 1, \dots, N \quad (3.8)$$

$$\frac{\partial \pi_{\mathcal{A}}}{\partial q_{PM}^A} = \alpha - 2\beta q_{PM}^A - 2\beta q_{PM}^B - \theta = 0 \quad (3.9)$$

$$\frac{\partial \pi_{\mathcal{A}}}{\partial q_{PF}^A} = \alpha - 2\beta q_{PF}^A - 2\beta q_{PF}^C - \theta = 0. \quad (3.10)$$

The economic interpretation of (3.6)-(3.10) is the following: Profit maximisation requires to equalise marginal revenue in each city-pair market  $xy$  with its associated marginal cost. Since the city-pair markets routing through the hub ( $iM, iF$ ) imply the use of two legs, the marginal cost associated with these markets is twice the marginal cost of the markets using one leg ( $iP, PM, PF$ ). Note that (3.9)-(3.10) correspond to the first order conditions associated to joint profit maximisation. The symmetry of the model allows us to concentrate on the symmetric joint profit maximising quantities where  $q_{PM}^A = q_{PM}^B$  and  $q_{PF}^A = q_{PF}^C$ . Solving the system (3.6)-(3.10) yields Airline  $\mathcal{A}$ 's optimal quantities:

$$q_{PM}^A = q_{PF}^A \equiv q_0^{col} = \frac{(\alpha - \theta)}{4\beta} = \frac{S}{4\beta} \quad (3.11)$$

$$Q_{iP} \equiv Q_1^{col} = \frac{(\alpha - \theta)}{2\beta} = \frac{S}{2\beta} \quad \text{for } i = 1, \dots, N \quad (3.12)$$

$$Q_{iM} = Q_{iF} \equiv Q_2^{col} = \frac{(\alpha - 2\theta)}{2\beta} = \frac{(S - \theta)}{2\beta}, \quad \text{for } i = 1, \dots, N \quad (3.13)$$

where  $S \equiv \alpha - \theta$ , and  $S > \theta$ . Notice that the symmetric structure reduces Airline  $\mathcal{A}$ 's maximisation problem to a three variables problem<sup>34</sup>.

Given (3.11)-(3.13), Airline  $\mathcal{A}$ 's static profit (3.5) can be expressed as a direct function of quantities/capacities (assuming implicitly that the profit function is a reduced form which subsumes instantaneous price competition). It can be shown that, in equilibrium

$$\pi_{\mathcal{A}}^{col} = \frac{1}{\beta} \left( \frac{S}{2} \right)^2 (N + 1) + \frac{1}{\beta} \left( \frac{S - \theta}{2} \right)^2 2N. \quad (3.14)$$

From (3.14), it appears that profit increases as the number of domestic legs,  $N$ , increases.

---

<sup>34</sup>As in Chapter 2, the model prevents arbitrage opportunities from arising. In effect, in order to prevent arbitrage opportunities, fares must be set such that the sum of the individual fares for the two legs of the trip (e.g.,  $iP$  plus  $PM$ ) is larger than the fare for a given city-pair market involving one stop (e.g.,  $iM$ ). If this were not the case, it would be profitable for the traveller to purchase the tickets separately. It can be shown that arbitrage opportunities are prevented throughout the chapter.

Next consider the case where Airline  $\mathcal{A}$  deviates and operates aircraft on the  $FM$  leg. Then, Airline  $\mathcal{A}$ 's profit function becomes

$$\begin{aligned}
\pi_{\mathcal{A}} = & \sum_{i=1}^N P(Q_{iP})Q_{iP} + \sum_{i=1}^N P(Q_{iM})Q_{iM} + \sum_{i=1}^N P(Q_{iF})Q_{iF} \\
& + P(Q_{PM})q_{PM}^{\mathcal{A}} + P(Q_{PF})q_{PF}^{\mathcal{A}} + P(Q_{FM})q_{FM}^{\mathcal{A}} \\
& - C_{l=pm}(q_{PM}^{\mathcal{A}} + \sum_{i=1}^N Q_{iM}) - C_{l=pf}(q_{PF}^{\mathcal{A}} + \sum_{i=1}^N Q_{iF}) \\
& - \sum_{i=1}^N C_{l=ip}(Q_{ip} + Q_{iF} + Q_{iM}) - C_{l=fm}(q_{FM}^{\mathcal{A}}). \tag{3.15}
\end{aligned}$$

From (3.15) it appears that:

1. Airline  $\mathcal{A}$ 's revenues are generated from  $3N + 3$  markets, while its costs correspond to aircraft flown on  $L = N + 3$  legs,
2. No fixed costs are associated with entry into the  $FM$  market, since Airline  $\mathcal{A}$  already serves both end points of the leg from its h-a-s airport,
3. In the  $FM$  market Airline  $\mathcal{A}$  competes with Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$ , therefore  $Q_{FM} = q_{FM}^{\mathcal{A}} + q_{FM}^{\mathcal{B}} + q_{FM}^{\mathcal{C}}$  and,
4. Airline  $\mathcal{A}$ 's total volume of traffic transported on the  $FM$  leg corresponds to the local,  $q_{FM}^{\mathcal{A}}$ , traffic only. Given our previous assumptions (see Section 3.3.2), the connecting passengers,  $Q_{jF}$  and  $Q_{kM}$ , for all  $j, k = 1, \dots, N$  are transported by Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$ , respectively. This explains why no connecting passengers appear in the last term of (3.15). It is important to notice, however, that since  $\gamma = 0$  (i.e., the returns to density are constant) Airline  $\mathcal{A}$ 's marginal cost of the  $FM$  passenger ( $\theta$ ) is equal to that of its rivals. Put differently, the two incumbents on the  $FM$  leg do not benefit from any (symmetric) absolute advantage in the  $FM$  market.

Given that Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  each produce the (collusive) monopoly quantity,  $S/4\beta$ , in the  $FM$  market, Airline  $\mathcal{A}$ 's optimal cheat strategy is to enter at its best-response quantity (i.e., to maximise profit on the residual demand). Consequently, maximisation of (3.15) implies that the  $3N + 2$  first order conditions (3.6)-(3.10) be satisfied and in addition,

$$\frac{\partial \pi_{\mathcal{A}}}{\partial q_{FM}^{\mathcal{A}}} = \alpha - 2\beta q_{FM}^{\mathcal{A}} - \beta\left(\frac{S}{2\beta}\right) - \theta = 0. \tag{3.16}$$

Solving the system (3.6)-(3.10) and (3.16) yields the Airline  $\mathcal{A}$ 's optimal quantities (3.11)-(3.13) and

$$q_{FM}^{\mathcal{A}} \equiv q_3^{dev} = \frac{(\alpha - \theta)}{4\beta} = \frac{S}{4\beta}. \tag{3.17}$$

This result suggests two remarks. First, in markets where internal conditions have not been altered by Airline  $\mathcal{A}$ 's deviation, the equilibrium quantities are identical. Second, for a given nonstop city-pair market, the total traffic transported is larger in the  $FM$  market ( $3S/4\beta$ ) than in the  $PM$  and  $PF$  markets ( $S/2\beta$ ).

Given (3.11)-(3.13) and (3.17), the reduced form of the static Airline  $\mathcal{A}$ 's deviation profit (3.15) can be expressed as

$$\pi_{\mathcal{A}}^{dev} = \frac{1}{\beta} \left( \frac{S}{2} \right)^2 (N + \frac{5}{4}) + \frac{1}{\beta} \left( \frac{S - \theta}{2} \right)^2 2N. \quad (3.18)$$

The difference between (3.18) and (3.14) corresponds to the additional short run profit associated with the entry in the  $FM$  leg and is equal to  $S^2/16\beta > 0$ .

After Airline  $\mathcal{A}$ 's deviation, it is assumed that Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  retaliate and enter simultaneously in the  $PF$  and  $PM$  markets. Consequently, after Airline  $\mathcal{A}$ 's deviation, a repeated static Cournot game is played on the intra-European  $FM$ ,  $PF$  and  $PM$  triopoly markets. Airline  $\mathcal{A}$ 's profit from retaliation (punishment) is given by a similar expression to (3.15) except that now,  $Q_{PM} = q_{PM}^A + q_{PM}^B + q_{PM}^C$  and  $Q_{PF} = q_{PF}^A + q_{PF}^B + q_{PF}^C$ . Given the symmetric structure of the model, we focus on the symmetric Cournot-Nash equilibria where  $q_{PM}^A = q_{PM}^B = q_{PM}^C$ ,  $q_{PF}^A = q_{PF}^B = q_{PF}^C$  and  $q_{FM}^A = q_{FM}^B = q_{FM}^C$ . The solution of Airline  $\mathcal{A}$ 's problem implies that the  $3N$  first order conditions (3.6)-(3.8) be satisfied and in addition,

$$\frac{\partial \pi_{\mathcal{A}}}{\partial q_{PM}^A} = \alpha - 2\beta q_{PM}^A - \beta(q_{PM}^B + q_{PM}^C) - \theta = 0 \quad (3.19)$$

$$\frac{\partial \pi_{\mathcal{A}}}{\partial q_{PF}^A} = \alpha - 2\beta q_{PF}^A - \beta(q_{PF}^B + q_{PF}^C) - \theta = 0 \quad (3.20)$$

$$\frac{\partial \pi_{\mathcal{A}}}{\partial q_{FM}^A} = \alpha - 2\beta q_{FM}^A - \beta(q_{FM}^B + q_{FM}^C) - \theta = 0. \quad (3.21)$$

Solving the system (3.6)-(3.8) and (3.19)-(3.21) yields Airline  $\mathcal{A}$ 's optimal quantities:

$$q_{PM}^A = q_{PF}^A = q_{FM}^A \equiv q_0^{pun} = \frac{(\alpha - \theta)}{4\beta} = \frac{S}{4\beta} \quad (3.22)$$

$$Q_{iP} \equiv Q_1^{pun} = \frac{(\alpha - \theta)}{2\beta} = \frac{S}{2\beta} \quad \text{for } i = 1 \dots, N \quad (3.23)$$

$$Q_{iM} = Q_{iF} \equiv Q_2^{pun} = \frac{(\alpha - 2\theta)}{2\beta} = \frac{(S - \theta)}{2\beta}. \quad \text{for } i = 1, \dots, N \quad (3.24)$$

Not surprisingly, for a given nonstop city-pair market, the equilibrium quantity provided in the triopoly markets,  $3S/4\beta$ , is larger than the quantity provided by the monopolist,  $S/2\beta$ . Note also that (3.23)-(3.24) are identical to (3.12)-(3.13) since, in these markets, internal conditions have not changed. However, following

the retaliation, Airline  $\mathcal{A}$  is “hurt” in two contested markets,  $PM$  and  $PF$ , since it produces the same quantity at a lower equilibrium price.

Given (3.22)-(3.24), the reduced form of the static Airline  $\mathcal{A}$ 's punishment profit can be expressed as

$$\pi_{\mathcal{A}}^{\text{pun}} = \frac{1}{\beta} \left( \frac{S}{2} \right)^2 \left( N + \frac{3}{4} \right) + \frac{1}{\beta} \left( \frac{S - \theta}{2} \right)^2 2N. \quad (3.25)$$

It can be shown that Airline  $\mathcal{B}$  (or Airline  $\mathcal{C}$ ) earns a greater profit by entering in  $\mathcal{A}$ 's markets than by staying where it is and maximising monopoly profit where it was doing so before. In other words, the threat is credible<sup>35</sup>.

Finally, I am able to investigate under which conditions the trigger strategy forms a subgame perfect equilibrium. Using (3.14), (3.18) and (3.25), Airline  $\mathcal{A}$ 's incentive constraint (3.1) must satisfy the following inequality:

$$\frac{1}{\beta} \left( \frac{S}{2} \right)^2 \left( \frac{1 - 2\delta}{4(1 - \delta)} \right) \leq 0.$$

This expression can be reduced to:

$$\delta_p \geq \frac{1}{2}.$$

Several comments are in order. First, the result is independent of the number of domestic legs,  $N$ , operated by each flag-carrier. This is due to the fact that partial liberalisation does not affect competition in the domestic legs when cost complementarities are absent (i.e., when  $\gamma = 0$ ) and when all city-pair markets are of equal size. Second, given that Airline  $\mathcal{A}$  cannot gain much from entry but has a great deal to lose, it is not surprising to find that  $\delta_p$  provides large opportunity for collusion. Finally, the  $\delta_p$  required for sustaining a noncooperative collusive outcome under partial liberalisation is independent of the underlying parameters of the demand and cost functions. This follows from the symmetry of the model.

<sup>35</sup>It has been argued that when players can freely (unlimitedly) discuss their strategies in a pre-play communication (without making binding agreements), a coalition of players might arrange plausible, mutually beneficial deviations from Nash agreements (see Bernheim et al. [1987]). Consequently, one should investigate to what extent the trigger strategy described above forms a Coalition-Proof Nash equilibrium. One way to examine this complex issue is to consider the incentive of a coalition of two flag-carriers, say Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$ , to jointly renege on the punishment equilibrium implied by the trigger strategy following Airline  $\mathcal{A}$ 's deviation. Dynamic consistency (coalition-proof equilibrium) requires that Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  equilibrium payoffs not be dominated by another feasible punishment, e.g., to accommodate Airline  $\mathcal{A}$ 's entry. In other words, the agreement (equilibrium) which specified that Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  enter into Airline  $\mathcal{A}$ 's markets and play a Cournot game forever, should Airline  $\mathcal{A}$ 's initial entry be observed, must be a coalition-proof equilibrium for the proper (punishment) subgame. It is not difficult to show that this result always holds under partial liberalisation. Unfortunately, such a clear-cut result does not occur under complete liberalisation because of the fixed costs associated with entry into a domestic leg. However, it can be shown that it holds for a reasonable range of fixed costs.

### 3.4.2 GAME II: Complete Liberalisation

The same approach as in Section 3.4.1 is followed except that now each flag-carrier might simultaneously enter into one seventh freedom leg (which corresponds to the previous case) and  $2N$  rivals' domestic legs according to the repeated game described in Section 3.3.1.

Let us first consider the case where each airline sticks to the existing bilateral agreements, i.e., where no use of seventh freedom and cabotage rights is made. This case is tantamount to the most collusive equilibrium outcome described in Section 3.4.1, with Airline  $\mathcal{A}$ , for example, operating aircraft on  $L = N + 2$  legs, serving  $3N + 2$  different city-pair markets and setting the monopoly quantity in the  $PM$  and  $PF$  markets. Accordingly, Airline  $\mathcal{A}$ 's profit function,  $\Pi_{\mathcal{A}}$ , is similar to (3.5), which implies that optimal quantities and profit are identical to (3.11)-(3.13) and (3.14).

Matters are quite different for the deviation and the punishment payoffs. Under complete liberalisation, Airline  $\mathcal{A}$ 's deviation profit function is given by

$$\begin{aligned}
 \Pi_{\mathcal{A}} = & \sum_{i=1}^N P(Q_{iP})Q_{iP} + \sum_{i=1}^N P(Q_{iM})Q_{iM} + \sum_{i=1}^N P(Q_{iF})Q_{iF} \\
 & + \sum_{k=1}^N P(Q_{kF})q_{kF}^{\mathcal{A}} + \sum_{k=1}^N P(Q_{kP})q_{kP}^{\mathcal{A}} + \sum_{k=1}^N P(Q_{kM})q_{kM}^{\mathcal{A}} \\
 & + \sum_{j=1}^N P(Q_{jF})q_{jF}^{\mathcal{A}} + \sum_{j=1}^N P(Q_{jP})q_{jP}^{\mathcal{A}} + \sum_{j=1}^N P(Q_{jM})q_{jM}^{\mathcal{A}} \\
 & + P(Q_{PM})q_{PM}^{\mathcal{A}} + P(Q_{PF})q_{PF}^{\mathcal{A}} + P(Q_{FM})q_{FM}^{\mathcal{A}} - 2NF \\
 & - C_{l=pm}(q_{PM}^{\mathcal{A}} + \sum_{i=1}^N Q_{iM} + \sum_{j=1}^N q_{jP}^{\mathcal{A}}) - C_{l=pf}(q_{PF}^{\mathcal{A}} + \sum_{i=1}^N Q_{iF} + \sum_{k=1}^N q_{kP}^{\mathcal{A}}) \\
 & - C_{l=fm}(q_{FM}^{\mathcal{A}} + \sum_{k=1}^N q_{kM}^{\mathcal{A}} + \sum_{j=1}^N q_{jF}^{\mathcal{A}}) - \sum_{i=1}^N C_{l=ip}(Q_{iP} + Q_{iF} + Q_{iM}) \\
 & - \sum_{k=1}^N C_{l=kf}(q_{kF}^{\mathcal{A}} + q_{kP}^{\mathcal{A}} + q_{kM}^{\mathcal{A}}) - \sum_{j=1}^N C_{l=jm}(q_{jM}^{\mathcal{A}} + q_{jP}^{\mathcal{A}} + q_{jF}^{\mathcal{A}}), \quad (3.26)
 \end{aligned}$$

where now,  $Q_{kF} = q_{kF}^{\mathcal{A}} + q_{kF}^{\mathcal{C}}$ ,  $Q_{kP} = q_{kP}^{\mathcal{A}} + q_{kP}^{\mathcal{C}}$ ,  $Q_{kM} = q_{kM}^{\mathcal{A}} + q_{kM}^{\mathcal{C}}$ ,  $Q_{jF} = q_{jF}^{\mathcal{A}} + q_{jF}^{\mathcal{B}}$ ,  $Q_{jP} = q_{jP}^{\mathcal{A}} + q_{jP}^{\mathcal{B}}$ ,  $Q_{jM} = q_{jM}^{\mathcal{A}} + q_{jM}^{\mathcal{B}}$ ,  $Q_{PM} = q_{PM}^{\mathcal{A}} + q_{PM}^{\mathcal{B}}$ ,  $Q_{PF} = q_{PF}^{\mathcal{A}} + q_{PF}^{\mathcal{C}}$ , and  $Q_{FM} = q_{FM}^{\mathcal{A}} + q_{FM}^{\mathcal{B}} + q_{FM}^{\mathcal{C}}$ .

From (3.26), it appears that:

1. Airline  $\mathcal{A}$ 's deviation implies that it operates aircraft on  $L = 3N + 3$  legs (instead of the previous  $N + 2$  legs) serving, according to the consumers'

preferences (see Section 3.3.2),  $9N + 3$  different city-pair markets<sup>36</sup>,

2. Among the  $9N + 3$  markets operated by Airline  $\mathcal{A}$ ,  $3N$  are monopoly markets,  $6N + 2$  are duopoly markets and, finally, one market is simultaneously operated by the three flag-carriers and,
3. Since entry into a domestic leg is associated with fixed costs,  $F$ , a deviation implies that Airline  $\mathcal{A}$  incurs fixed costs equal to  $2NF$ .

As before, Airline  $\mathcal{A}$ 's optimal deviation strategy is to enter at its best-response quantity given that Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  each produce the collusive output in the  $FM$  market ( $S/4\beta$ ) and the monopoly output in their previous domestic markets ( $S/2\beta$  and  $(S - \theta)/2\beta$ ). Assuming interior solutions to the maximisation of (3.26), the solution of Airline  $\mathcal{A}$ 's problem implies that (3.6)-(3.10) and the following  $6N + 1$  first order conditions be satisfied simultaneously:

$$\frac{\partial \Pi_{\mathcal{A}}}{\partial q_{kF}^{\mathcal{A}}} = \alpha - 2\beta q_{kF}^{\mathcal{A}} - \beta\left(\frac{S}{2\beta}\right) - \theta = 0 \quad \text{for } k = 1, \dots, N \quad (3.27)$$

$$\frac{\partial \Pi_{\mathcal{A}}}{\partial q_{kP}^{\mathcal{A}}} = \alpha - 2\beta q_{kP}^{\mathcal{A}} - \beta\left(\frac{S-\theta}{2\beta}\right) - 2\theta = 0 \quad \text{for } k = 1, \dots, N \quad (3.28)$$

$$\frac{\partial \Pi_{\mathcal{A}}}{\partial q_{kM}^{\mathcal{A}}} = \alpha - 2\beta q_{kM}^{\mathcal{A}} - \beta\left(\frac{S-\theta}{2\beta}\right) - 2\theta = 0 \quad \text{for } k = 1, \dots, N \quad (3.29)$$

$$\frac{\partial \Pi_{\mathcal{A}}}{\partial q_{jM}^{\mathcal{A}}} = \alpha - 2\beta q_{jM}^{\mathcal{A}} - \beta\left(\frac{S}{2\beta}\right) - \theta = 0 \quad \text{for } j = 1, \dots, N \quad (3.30)$$

$$\frac{\partial \Pi_{\mathcal{A}}}{\partial q_{jF}^{\mathcal{A}}} = \alpha - 2\beta q_{jF}^{\mathcal{A}} - \beta\left(\frac{S-\theta}{2\beta}\right) - 2\theta = 0 \quad \text{for } j = 1, \dots, N \quad (3.31)$$

$$\frac{\partial \Pi_{\mathcal{A}}}{\partial q_{jP}^{\mathcal{A}}} = \alpha - 2\beta q_{jP}^{\mathcal{A}} - \beta\left(\frac{S-\theta}{2\beta}\right) - 2\theta = 0 \quad \text{for } j = 1, \dots, N \quad (3.32)$$

$$\frac{\partial \pi_{\mathcal{A}}}{\partial q_{FM}^{\mathcal{A}}} = \alpha - 2\beta q_{FM}^{\mathcal{A}} - \beta\left(\frac{S}{2\beta}\right) - \theta = 0. \quad (3.33)$$

Solving the system (3.6)-(3.10) and (3.27)-(3.33) yields Airline  $\mathcal{A}$ 's optimal quantities from deviation. These quantities correspond to (3.11)-(3.13), (3.17) and, in order to take the new opportunities of entry into account,

$$q_{kF}^{\mathcal{A}} = q_{jM}^{\mathcal{A}} \equiv q_0^{Dev} = \frac{(\alpha - \theta)}{4\beta} = \frac{S}{4\beta} \quad \text{for } k, j = 1, \dots, N \quad (3.34)$$

$$q_{kP}^{\mathcal{A}} = q_{kM}^{\mathcal{A}} = q_{jF}^{\mathcal{A}} = q_{jP}^{\mathcal{A}} \equiv q_4^{Dev} = \frac{(\alpha - 2\theta)}{4\beta} = \frac{(S - \theta)}{4\beta}. \quad \text{for } k, j = 1, \dots, N \quad (3.35)$$

Given (3.11)-(3.13), (3.17), (3.34)-(3.35) and (3.26), the reduced form of the static Airline  $\mathcal{A}$ 's deviation profit can be expressed as

$$\Pi_{\mathcal{A}}^{Dev} = \frac{1}{\beta} \left( \frac{S}{2} \right)^2 \left( \frac{6N + 5}{4} \right) + \frac{1}{\beta} \left( \frac{S - \theta}{2} \right)^2 3N - 2NF > 0. \quad (3.36)$$

<sup>36</sup>As an example, when  $N = 1$  (as Figure 3.1 suggests), Airline  $\mathcal{A}$  operates aircraft on 6 legs, serving 12 different city-pair markets.

After Airline  $\mathcal{A}$ 's deviation, it is assumed that Airline  $\mathcal{B}$  and Airline  $\mathcal{C}$  retaliate and simultaneously enter in all the markets throughout the network, i.e., they make use of their seventh freedom and cabotage rights granted under the complete liberalisation of the industry. As a consequence, after Airline  $\mathcal{A}$ 's deviation, a repeated static Cournot game is played on the  $9N + 3$  different city-pair markets, with each flag-carrier operating aircraft on  $L = 3N + 3$  legs. Airline  $\mathcal{A}$ 's profit from punishment is given by an expression similar to (3.26) except that now,  $Q_{xy} = \sum_f q_{xy}^f$ , with  $f = \mathcal{A}, \mathcal{B}, \mathcal{C}$ , for all  $xy$  of the network. Consider the symmetric Cournot-Nash equilibria where  $q_{xy}^{\mathcal{A}} = q_{xy}^{\mathcal{B}} = q_{xy}^{\mathcal{C}}$ , for all  $xy$  in the network. In that case, it can be verified that Airline  $\mathcal{A}$ 's optimal quantities are:

$$q_{PM}^{\mathcal{A}} = q_{PF}^{\mathcal{A}} = q_{FM}^{\mathcal{A}} = q_{kF}^{\mathcal{A}} = q_{jM}^{\mathcal{A}} = q_{iP}^{\mathcal{A}} = \frac{(\alpha - \theta)}{4\beta} = \frac{S}{4\beta}, \quad \text{for all } i, k, j = 1, \dots, N \quad (3.37)$$

$$q_{iM}^{\mathcal{A}} = q_{iF}^{\mathcal{A}} = q_{kP}^{\mathcal{A}} = q_{kM}^{\mathcal{A}} = q_{jF}^{\mathcal{A}} = q_{jP}^{\mathcal{A}} = \frac{(\alpha - 2\theta)}{4\beta} = \frac{(S - \theta)}{4\beta}. \quad \text{for all } i, k, j = 1, \dots, N \quad (3.38)$$

It is important to notice that, following the retaliation, Airline  $\mathcal{A}$  is "hurt" in  $3N + 2$  contested markets, i.e., exactly all the markets it served prior to the deviation<sup>37</sup>. Given (3.37)-(3.38) and (3.26), the reduced form of the static Airline  $\mathcal{A}$ 's punishment profit is

$$\Pi_{\mathcal{A}}^{Pun} = \frac{1}{\beta} \left( \frac{S}{2} \right)^2 \left( \frac{3N + 3}{4} \right) + \frac{1}{\beta} \left( \frac{S - \theta}{2} \right)^2 \left( \frac{3N}{2} \right) - 2NF > 0. \quad (3.39)$$

Finally, using (3.14), (3.36) and (3.39), Airline  $\mathcal{A}$ 's incentive constraint (3.2) must satisfy the following inequality in a subgame perfect equilibrium:

$$\frac{1}{\beta} \left( \frac{S}{2} \right)^2 \left[ \frac{2N + 1 - \delta(3N + 2)}{4(1 - \delta)} \right] + \frac{1}{\beta} \left( \frac{S - \theta}{2} \right)^2 \left[ \frac{N(4 - 6\delta)}{4(1 - \delta)} \right] - \left[ \frac{2NF}{1 - \delta} \right] \leq 0.$$

The discount factor which sustains a noncooperative collusive outcome under complete liberalisation,  $\delta_c$ , is given by

$$\delta_c \geq \frac{S^2(2N + 1) + 4N(S - \theta)^2 - 32NF\beta}{S^2(3N + 2) + 6N(S - \theta)^2}.$$

This result suggests the following remarks:

---

<sup>37</sup>This result should be contrasted with the partial liberalisation case, where Airline  $\mathcal{A}$  was hurt in two markets.



1. Since  $\delta_c > 0$ , in equilibrium  $F < \frac{1}{32N\beta}[S^2(2N+1) + 4N(S-\theta)^2] \equiv F^*$ . It can be shown that the threat is credible for fixed costs,  $F$ , lower than the threshold  $F^*$ <sup>38</sup>. Therefore, the model allows for fixed costs but these must not be excessively high<sup>39</sup>. Notice that when this condition is satisfied, both profit functions (3.36) and (3.39) are positive.
2. It is easy to verify that as  $F$  increase,  $\delta_c(\cdot)$  decreases monotonically, suggesting that for a given collusive outcome the required discount factor becomes smaller as the fixed cost per leg increases.
3. For  $N \neq 0$  and/or  $F \neq 0$ ,  $\delta_c$  is a function of the underlying parameters of the demand and cost functions and the number of domestic legs.

The relation between  $\delta_c(\cdot)$  and  $N$  turns out to be important for the analysis that follows. Assume that the network is sufficiently large to allow us to treat  $N$  as a continuous variable. We can show that, in equilibrium,

$$\frac{\partial \delta_c}{\partial N} = \frac{S^2[S^2 + 2(S-\theta)^2 - 64F\beta]}{[S^2(3N+2) + 6N(S-\theta)^2]^2} \geq (<)0.$$

Therefore, two cases should be considered:

CASE I: Low Fixed Cost  $F < \frac{1}{64\beta}[S^2 + 2(S-\theta)^2] \equiv F_0$

In CASE I,  $F < F_0$  and, as  $N$  increases, the discount factor,  $\delta_c$ , required for the trigger strategy to form a subgame perfect equilibrium increases. This result suggests that, for sufficiently small entry costs, when cabotage rights are granted to flag-carriers, the larger the network the more difficult it is to sustain collusion. In other words, the stability of the bilateral agreements is more difficult to attain when, *ceteris paribus*, multi-market flag-carriers operate large H&S networks and fixed costs associated with entry are small.

CASE II: High Fixed Cost  $F > \frac{1}{64\beta}[S^2 + 2(S-\theta)^2] \equiv F_0$

In CASE II,  $F > F_0$  and, as  $N$  increases, the discount factor,  $\delta_c$ , required for the trigger strategy to form a subgame perfect equilibrium decreases. Consequently, an opposite conclusion to CASE I ensues: For fixed costs higher than  $F_0$ , the larger the network, *ceteris paribus*, the easier it is to sustain some degree of cooperation.

I am now able to summarise the preceding results and to state the following proposition:

<sup>38</sup>In other words, the profit of, say, Airline  $B$  by not retaliating given that Airline  $A$  has defected and Airline  $C$  retaliates, would be lower than  $\Pi_B^{pun}$ .

<sup>39</sup>In fact, this upper bound is not binding for a large range of parameters.

**Proposition 1** *Under CASE I, the scope for sustainable collusion with a trigger strategy is strictly larger under partial liberalisation (as defined in Section 3.3). The opposite result is obtained under CASE II: The scope for sustainable collusion with a trigger strategy is strictly larger under complete liberalisation (as defined in Section 3.3).*

The proof consists in comparing the required discount factors,  $\delta_c$  and  $\delta_p$ , for the trigger strategy to form a subgame perfect equilibrium.

**Proof 1**

$$\begin{aligned}\delta_c \geq (<) \delta_p &\iff \frac{S^2(2N+1) + 4N(S-\theta)^2 - 32NF\beta}{S^2(3N+2) + 6N(S-\theta)^2} \geq (<) \frac{1}{2} \\ &\implies NS^2 + 2N(S-\theta)^2 - 64NF\beta \geq (<) 0 \\ &\implies F \leq (>) \frac{1}{64\beta} [S^2 + 2(S-\theta)^2] \equiv F_0 < F^* \quad \square.\end{aligned}$$

Notice that in equilibrium, for  $N \neq 0$ , it is always verified that  $F_0 < F^*$ . In effect:

$$\begin{aligned}F^* > F_0 &\iff \frac{1}{32N\beta} [S^2(2N+1) + 4N(S-\theta)^2] > \frac{1}{64\beta} [S^2 + 2(S-\theta)^2] \\ &\implies S^2(3N+2) + 6N(S-\theta)^2 > 0, \quad \text{which is always true.}\end{aligned}$$

Thus, in CASE II, the upper and lower bounds on  $F$  are given by  $F^* > F > F_0$ .

**Corollary 1** *When  $F = 0$ , the range in which flag-carriers can sustain collusive equilibria is always larger under partial liberalisation. If  $N = 0$  and/or  $F = F_0$ , the most collusive outcome is sustainable if the discount factor is larger than  $1/2$  under both regulatory regimes. Notice that when  $N = 0$ , flag-carriers do not operate domestic legs and, as a consequence, cabotage rights are not effective: Partial and complete liberalisation outcomes are identical.*

Finally, it is interesting to note that the collusive outcome is not always socially undesirable. In particular, it can be shown that under complete liberalisation net social welfare<sup>40</sup> is larger under the collusive outcome *when* fixed costs are higher than<sup>41</sup>  $\frac{3}{64N\beta} [S^2(N+1) + 2N(S-\theta)^2] \equiv F^w$ . This happens because during the punishment phase (competitive phase), the fixed costs incurred by all flag-carriers lead to productive inefficiencies throughout the network. Given the absence of fixed costs associated with entry into intra-European legs, the collusive outcome is clearly not socially desirable under partial liberalisation.

<sup>40</sup>Defined as the sum of consumers' surplus on each market  $xy$  plus the economic profit of the industry.

<sup>41</sup>To obtain this result, one must compare welfare under collusion with welfare under retaliation over the entire network. Note that for  $N \neq 0$ ,  $F^w < F^*$ , in equilibrium.

In summary, the results of Proposition 1 suggest that, *under low fixed costs*, complete liberalisation is more likely to promote competition since a collusive outcome is more difficult to sustain, especially when the network is large. In contrast, *for high fixed costs* the analysis reveals that complete liberalisation provides a relatively larger opportunity to sustain collusion (even if tacit collusion is pervasive under partial liberalisation). Consequently, a simple EU policy implication of this chapter could be stated as follows: Grant cabotage rights, i.e., complete liberalisation. If barriers to entry are significant, then work towards reducing fixed costs and institutional barriers.

### 3.4.3 Illustration and Numerical Example

In order to illustrate these results, let us first consider the following figures. Figure 3.3 and Figure 3.4 (see Appendix page 119) exhibit the profile of required discount factors, as a function of the number of domestic legs. Since  $N$  is a positive integer,  $\delta_c(\cdot)$  is a step function or piecewise constant function. As shown in Figure 3.3,  $\delta_c(\cdot)$  increases at a decreasing rate under CASE I. Under CASE II,  $\delta_c(\cdot)$  is a decreasing function as can be observed in Figure 3.4.

Figure 3.5 (see Appendix page 120) exhibits the range of equilibria for the intermediate case where  $F = F_0$ . As suggested by Corollary 1, the most collusive outcome is sustainable if the discount factor is larger than  $1/2$  under both regulatory regimes.

Figure 3.6 (see Appendix page 120) exhibits the range of equilibria as a function of  $F$  when  $N = N_0 > 0$ . For a given number of domestic markets,  $\delta_c$  decreases monotonically as  $F$  increases.

Table 3.2 provides a numerical example for  $\beta = 1, \alpha = 10, \theta = 2$ , and  $N = 0, 1, 2, 3, 4$ . In that case,  $F_0 = \frac{17}{8} = 2.125$ . Accordingly, CASE I would correspond to, e.g.,  $F = 1$ , while CASE II would correspond to, e.g.,  $F = 3$ .

Table 3.2: Numerical Example

$\beta = 1$ $\alpha = 10$ $\theta = 2$	CASE I $1 = F < F_0 = \frac{17}{8}$	$F = F_0 = \frac{17}{8}$	CASE II $3 = F > F_0 = \frac{17}{8}$
$N = 0$	$\delta_c = \delta_p \geq \frac{1}{2}$	$\delta_c = \delta_p \geq \frac{1}{2}$	$\delta_c = \delta_p \geq \frac{1}{2}$
$N = 1$	$\delta_c \geq \frac{38}{67}$ and $\delta_c > \delta_p \geq \frac{1}{2}$	$\delta_c = \delta_p \geq \frac{1}{2}$	$\delta_c \geq \frac{30}{67}$ and $\delta_c < \frac{1}{2} \leq \delta_p$
$N = 2$	$\delta_c \geq \frac{34}{59}$ and $\delta_c > \delta_p \geq \frac{1}{2}$	$\delta_c = \delta_p \geq \frac{1}{2}$	$\delta_c \geq \frac{25}{59}$ and $\delta_c < \frac{1}{2} \leq \delta_p$
$N = 3$	$\delta_c \geq \frac{98}{169}$ and $\delta_c > \delta_p \geq \frac{1}{2}$	$\delta_c = \delta_p \geq \frac{1}{2}$	$\delta_c \geq \frac{74}{169}$ and $\delta_c < \frac{1}{2} \leq \delta_p$
$N = 4$	$\delta_c \geq \frac{32}{55}$ and $\delta_c > \delta_p \geq \frac{1}{2}$	$\delta_c = \delta_p \geq \frac{1}{2}$	$\delta_c \geq \frac{24}{55}$ and $\delta_c < \frac{1}{2} \leq \delta_p$

### 3.5 Concluding Remarks

In this chapter, I establish under what conditions a trigger strategy can be sustained under both regulatory regimes. I demonstrate that, for sufficiently low fixed costs, to be precise  $F < F_0$ , flag-carriers are more likely to sustain noncooperative collusive outcomes under partial liberalisation of the European airline industry. When fixed costs are nil, the range of discount factors over which tacit collusion can be sustained is always larger under partial liberalisation. I show, concomitantly, that when fixed costs associated with entry into domestic legs are high,  $F > F_0$ , the discount factor required to sustain the trigger strategy equilibrium is, *ceteris paribus*, lower under complete liberalisation. In this latter case, the high fixed costs act like a natural entry deterrent and flag-carriers are less eager to exploit new entry opportunities provided by the liberalisation of the industry. This appealing result is congruent with standard oligopoly theory. Flag-carriers that repeatedly meet each other in different markets are aware of their “spheres of influence”, spheres where they have an absolute or relative cost advantage, and recognise that an entry with high fixed costs would not be privately profitable. Moreover, I highlight an interesting relationship between the size of the network and the ease of sustaining collusion. When fixed costs are low, the larger the domestic network the higher the discount factor required for sustaining collusion, while when fixed costs are high, the larger the network the lower the discount factor required for sustaining collusion. This result implies that for large networks and large fixed costs, collusive outcomes are easier to sustain in equilibrium.

There are some interesting policy implications. First, Section 3.4.1 suggests that flag-carriers have large opportunities for sustaining collusion, given the low threshold of  $\delta_p$ , under partial liberalisation. This is due to the fact that, in this three-airline model, as a flag-carrier enters into one intra-European leg (one market) it hurts simultaneously two rivals, which are supposed to retaliate. Consequently, the flag-carrier which decides to enter in that leg, expects to be hurt in two legs (two markets). This is an inherent implication of the seventh freedom competition in the European airline industry. Second, Section 3.4.2 shows how fixed costs play an important role under complete liberalisation, given that a flag-carrier is likely to have a competitive advantage in its domestic leg. Fixed costs may be high as a result of a [rival] flag-carrier's airport and/or route dominance. I find that, for a given number of domestic legs operated in the network, the lower the fixed costs, the higher is the incentive to enter and deviate from past bilateral agreements. Complete liberalisation provides the opportunity to operate a larger network so that reaping general short-run gains (i.e., deviating) could turn out to be a successful strategy when fixed costs are low and flag-carriers have relatively high impatience (or a high  $\delta$ ). If fixed costs are high, the incentive to deviate is, *ceteris paribus*, lower and collusion is more likely to be sustained under complete liberalisation.

Thus, even if complete liberalisation of the European airline industry gives the opportunity to any EU airline to have access to any intra-EU routes, it may be the case that airlines are better off sticking to past bilateral agreements. This is more likely to occur when airlines operate large domestic networks and it is costly to run a new business into rivals' domestic niches. Clearly, institutional constraints on the European airline industry, like congested airports and air space, raise the fixed costs associated with entry. Many airline experts recognise that the shortage of airport capacity is likely to put incumbent flag-carriers in a much better opportunity to block entry by purchasing or leasing most of the gates at the home airport, thereby raising rivals' fixed costs. Furthermore, as stressed by Borenstein [1992], the potential for home-country bias is intensified in this industry because so much of the infrastructure needed by airlines is publicly provided. In fact, Borenstein [1992] argues that the commercial success of an airline entry into a new leg depends on local governments and local airport managers who can play a substantial role in determining key features such as the use of airport facilities, convenience of connections, etc.. Our results suggest that barriers to entry into domestic niches should be minimised if EU authorities or national governments want to promote competition (or restrict noncooperative collusion) in this industry. To this end, any removal of institutional barriers could provide a signal for flag-carriers to act more competitively.

Finally, the model suggests that for relatively high fixed costs,  $F^w < F < F^*$ , the collusive outcome is not socially undesirable under complete liberalisation because competition leads to high productive inefficiencies.

I think that the main results of this chapter are likely to hold under a variety of different demand and cost structures because they are driven by the network H&S structure and by the fixed costs associated with entry. One could argue that allowing for increasing returns to density would reproduce more accurately airlines H&S operations. What are the results if airlines face increasing returns to density ( $\gamma > 0$ )? By assuming constant returns to density, I avoid the complexity of the analysis with respect to, first, the existence of (unique) equilibria<sup>42</sup> and second, with respect to (internal) strategic effects of cost-based linkages across markets. In this latter case, when returns to traffic density are increasing, entry into a new leg affects the marginal cost of the incumbent rivals throughout the network and introduces cost asymmetries between flag-carriers. For example, entry into the intra-European leg would (a) increase the marginal cost of the passenger in that leg since traffic per airline is lower, (b) increase the marginal cost of the connecting passenger using that leg, therefore affecting also the domestic (monopoly) markets and, (c) create a (symmetric) cost disadvantage if the total volume of traffic the entrant flag-carrier generates on the new leg is lower than that of its incumbent rivals (i.e., the entrant would be less efficient in that leg). As a consequence, with

---

<sup>42</sup>The quasiconcavity of the profit function is necessarily to help ensure existence of a trigger strategy equilibrium (see, for example, Friedman [1991]).

cost complementarities, an entry has widespread effects on the H&S network and flag-carriers are likely to be aware of these effects. Accordingly, it may well be the case that, when returns to density are increasing, the range of discount factors over which flag-carriers can sustain collusion is more important under both regulatory schemes<sup>43</sup>. As a consequence, whether a particular scheme enhances flag-carriers to sustain collusion remains an interesting but difficult question to answer *when* cost complementarities arise. Further research is clearly needed. Note also that, by avoiding to deal explicitly with returns to density, the policy implications from this chapter are not mainly an empirical question.

The analysis could be extended in several directions. First, it would be interesting to analyse how the range of discount factors is modified under (product) air service differentiation in a quantity setting framework<sup>44</sup>. Second, some asymmetries could be introduced such as different city-pair market growth rates, (for example, intra-European markets could grow at a higher rate than domestic markets), different marginal costs and/or different network sizes among flag-carriers. Third, the model could allow for entry into the network by smaller (regional) airlines. A smaller airline could incur additional (sunk) costs with respect to incumbent flag-carriers. Finally, one might test to what extent the European airline industry actually is in the "mutual forbearance" equilibrium described above.

As a final remark, throughout the chapter I have assumed that flag-carriers always seek profit maximisation. This is clearly a strong assumption for flag-carriers which are partly or entirely publicly owned. However, the successful privatisation of the largest European flag-carrier, British Airways, has seemed to speed up the privatisation of most European flag-carriers (e.g., Lufthansa) and, as a consequence, one might suppose that profit maximisation becomes a reasonable objective. Having said this does not prevent me from thinking that, in this industry, the economics of national pride are still at work.

### 3.6 References

- ABREU, D., 1988, "On the Theory of Infinitely Repeated Games with Discounting," *Econometrica*, 56, pp.383-396.
- BAILEY, E.E. and PANZAR, J.C., 1981, "The Contestability of Airline Markets During the Transition to Deregulation," *Law and Contemporary Problems*, 44, pp.125-145.
- BARLA, P., 1992, "Multimarket Contact and Pricing Strategy in the U.S. Domestic Airline Sector," International Centre of Research and Information on

<sup>43</sup>Note that welfare need not necessarily be lower under collusion when returns to traffic density are important.

<sup>44</sup>The inverse demand function (3.3) would become  $P_{xy}^f = A - bq_{xy}^f - d \sum_{t \neq f} q_{xy}^t$ , where  $d \geq 0$  is the differentiation parameter and  $f, t = A, B, C$ .

the Public and Cooperative Economics, Belgium.

**BENOIT, J.P. and KRISHNA, V.**, 1987, "Dynamic Duopoly: Prices and Quantities," *Review of Economic Studies*, 54, pp.23-35.

**BERNHEIN, B.D., PELEG, B. and WHINSTON, M.D.**, 1987, "Coalition-Proof Nash Equilibria I. Concepts," *Journal of Economic Theory*, 42, pp.1-12.

**BERNHEIM, B.D. and WHINSTON, M.D.**, 1990, "Multimarket Contact and Collusive Behavior," *Rand Journal of Economics*, 21, pp.1-26.

**BORENSTEIN, S.**, 1992, "Prospects for Competitive Air Travel in Europe," *Europe After 1992*, W.J. Adams, eds., The University of Michigan Press.

**BRANDER, J.A. and ZHANG, A.**, 1990, "Market Conduct in the Airline Industry: an Empirical Investigation," *Rand Journal of Economics*, 21, pp.567-583.

**BRANDER, J.A. and ZHANG, A.**, 1993, "Dynamic Oligopoly Behaviour in the Airline Industry," *International Journal of Industrial Organization*, 11, pp.407-435.

**BRUECKNER, J.K. and SPILLER, P.T.**, 1991, "Competition and Mergers in Airline Networks," *International Journal of Industrial Organization*, 9, pp.323-342.

**CAVES, D.W., CHRISTENSEN, L.R. and TRETHERWAY, M.W.**, 1984, "Economies of Density versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ," *Rand Journal of Economics*, 15, pp.471-489.

**EDWARDS, C.D.**, 1955, "Conglomerate Bigness as a Source of Power," in *Business Concentration and Price Policy*, NBER Conference Report, Princeton University Press.

**ENCAOUA, D. and PERROT, A.**, 1991: *Concurrence et Coopération dans le Transport Aérien*, Commission of the European Communities, Brussels.

**EVENS, W.N. and KESSIDES, I.N.**, 1993, "Structure, Conduct, and Performance in the Deregulated Airline Industry," *Southern Economic Journal*, 59, pp.450-467.

**EVENS, W.N. and KESSIDES, I.N.**, 1994, "Living by the "Golden Rule": Multimarket Contact in the U.S. Airline Industry," *Quarterly Journal of Economics*, 109, pp.341-366.

**FRIEDMAN, J.W.**, 1971, "A Noncooperative Equilibrium for Supergames," *Review of Economic Studies*, 28, pp.1-12.

- FRIEDMAN, J.W.**, 1991, *Game Theory with Applications to Economics*, New York: Oxford University Press, Second Edition.
- FUDENBERG, D. and TIROLE, J.**, 1991, *Game Theory*, Cambridge: MIT Press.
- KAHN, A.E.**, 1950, "The Chemicals Industry," *The Structure of American Industry: Some Case Studies*, Walter Adams, eds., New York: Macmillan, pp.197-230.
- KIM, E.H. and SINGAL, V.**, 1993, "Mergers and Market Power: Evidence From the Airline Industry," *American Economic Review*, 83, pp.549-569.
- KREPS, D.M. and SCHEINKMAN, J.A.**, 1983, "Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes," *Bell Journal of Economics*, 14, pp.326-337.
- LEVINE, M.E.**, 1987, "Airline Competition in a Deregulated Market: Theory, Firm Strategy, and Public Policy," *Yale Journal on Regulation*, 4, pp.393-494.
- MARTIN, S.**, 1993, *Advanced Industrial Economics*, Oxford: Blackwell Publishers.
- OUM, T.H. and TRETHERWAY, M.W.**, 1992, *Airline Economics: Foundations for Strategy and Policy*, Centre for Transportation Studies, University of British Columbia.
- PAVAUX, J.**, 1984, *L'Economie du Transport Aérien: La Concurrence Impraticable*, Paris: Economica.
- PHILIPS, L.**, 1988, *The Economics of Imperfect Information*, Cambridge: Cambridge University Press.
- RASMUSEN, E.**, 1994, *Games and Information*, Second Edition, Blackwell Publishers, Cambridge, Massachusetts.
- REES, R.**, 1994, "Tacit Collusion," *Oxford Review of Economic Policy*, 9, pp.27-40.
- STIGLER, G.J.**, 1964, "A Theory of Oligopoly," *Journal of Political Economy*, 72, pp.44-61.
- TIROLE, J.**, 1988, *The Theory of Industrial Organization*, Cambridge: MIT Press.
- ZANG, A. and WEI, X.**, 1993, "Competition in Airline Networks: The Case of Constant Elasticity Demand," *Economics Letters*, 42, pp.253-259.



### 3.7 Appendix

Figure 3.3: Range of Equilibria for  $\delta_c$  and  $\delta_p$  under CASE I

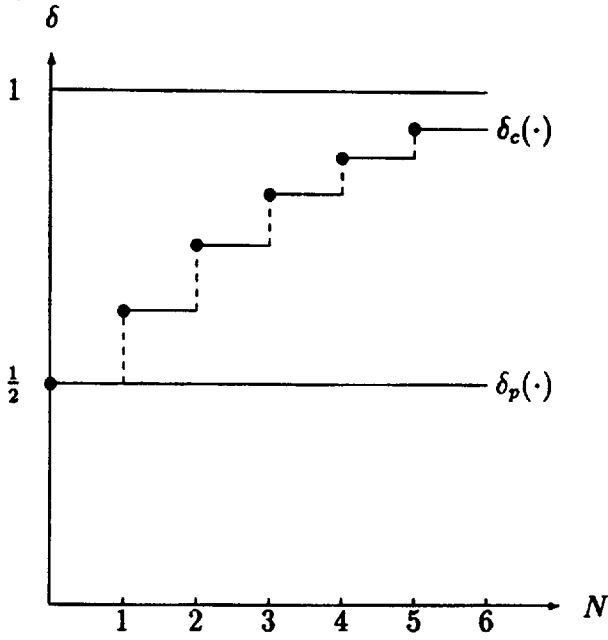


Figure 3.4: Range of Equilibria for  $\delta_c$  and  $\delta_p$  under CASE II

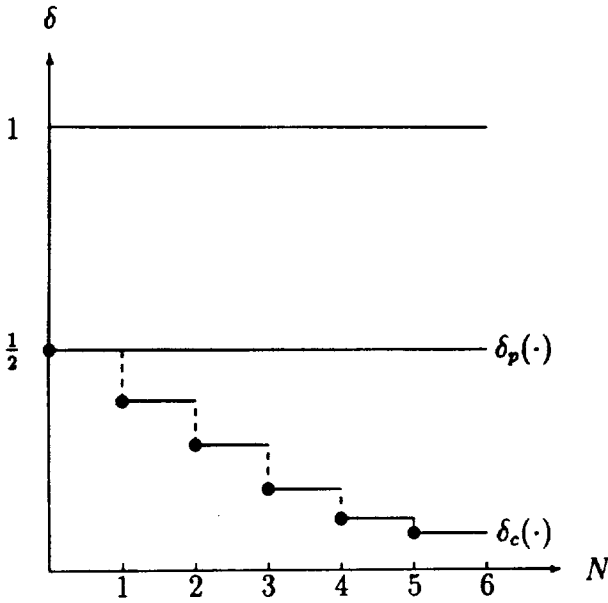


Figure 3.5: Range of Equilibria for  $\delta_c$  and  $\delta_p$  when  $F = F_0$

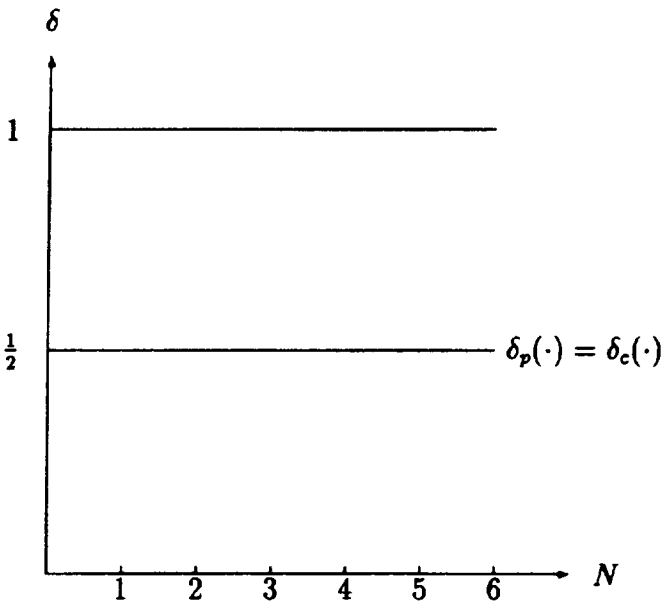
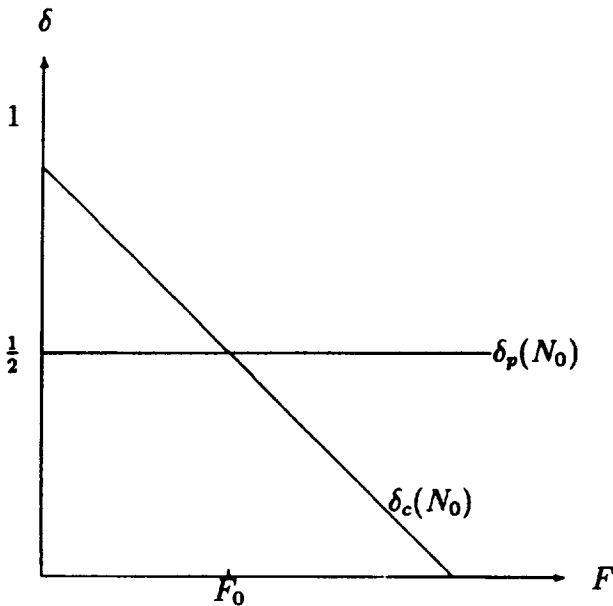


Figure 3.6: Range of Equilibria for  $\delta_c$  and  $\delta_p$  as a Function of  $F$



# Chapter 4

## Spatial Multiproduct Duopoly with Finite and Small (Enough) Reservation Price

### 4.1 Introduction

The observation of modern real world business highlights at least two main features: First, a single firm generally produces more than one product and second, a specific industry provides a range of differentiated products. Indeed, it is difficult to find examples of single product firms or markets where single product firms sell one homogeneous product only<sup>1</sup>. Two of the most important questions a successful firm must answer are (1) how many different products to sell, and (2) how much should these products be differentiated ? These questions have been

recently addressed within the framework developed by Hotelling's [1929] seminal paper on spatial competition. Martinez-Giralt & Neven [1988] study a spatial multiproduct oligopoly model assuming that the number of products sold by each firm and their positions (in characteristics space) are determined endogenously. They restrict their analysis to two firms with two (potential) products each. They obtain the following 'negative' result: In a two stage game, each firm chooses to sell or produce a single product at equilibrium. This is because, when a firm adds a second product it a) increases its market share (positive effect) and b) increases price competition (negative price effect). Using the standard assumptions of a spatial model, they show that the positive impact of adding a new product is dominated by the negative effect. This somewhat surprising result suggests that other features should be added to explain the existence of multiproduct firms. In their concluding remarks, Martinez-Giralt & Neven suggest that multi-outlet

---

<sup>1</sup>White salt, steel plates, Portland cement, mineral water may constitute different examples of homogeneous markets. However, this does not preclude these firms to produce several homogeneous products. As an example, *San Benedetto*, a major Italian mineral water company, retails in the Florentine stores two different brands of mineral water: 'Fonte Guizza Naturale' and 'San Benedetto Naturale'.

competition should be modelled by allowing for ‘additional ingredients such as elastic demand, economies of scope or the threat of entry’. Using the same framework, Bensaid & de Palma [1994] subsequently show that when more than two firms operate in the market, multiproduct equilibria emerge because a single outlet firm always has an incentive to introduce a second outlet when it faces two or more competing firms.

In this chapter, I construct an example to show how multiproduct duopoly equilibria emerge when firms face an elastic demand and consumers have a finite and small reservation price. The introduction of a second outlet allows duopolists to charge a higher mill price. When this price effect is added to the positive market effect, duopolists are unambiguously better off after the introduction of a second outlet. Moreover, I show that it is socially optimal to provide a larger number of differentiated goods.

This chapter is organised as follows. The basic concepts of spatial competition and product differentiation are defined in Section 4.2. Section 4.2 also provides an interesting analogy between space location, product differentiation and transport scheduling, such that the framework developed throughout this chapter can be used to analyse some relevant features of intra-EU airline competition. Section 4.3 introduces the assumptions. The main results are presented in Section 4.4. Section 4.5 concludes.

## 4.2 Spatial Competition and Models of Product Differentiation: Some Basic Definitions

The ingredients of the present chapter and Chapter 5 are derived from the literature on product differentiation models and spatial (imperfect) competition models. Before presenting the theoretical model, it is useful to clarify some basic definitions of product differentiation models. The first important distinction to be made is between **horizontal product differentiation** and **vertical product differentiation**. Two varieties of a product are said to be vertically differentiated when one variety contains more of some or all characteristics than the second, so that rational consumers given a free choice would unambiguously choose the “better” variety. As an example, a Mercedes and a Skoda would be two vertically differentiated cars since it is generally assumed that the Mercedes contains more of some or all characteristics (comfort, speed, power, etc.) than the Skoda (in other words, Mercedes is perceived as a higher quality car). In contrast, two varieties of a product are said to be horizontally differentiated when one contains more of some but fewer of other characteristics, so that two consumers offered a free choice would not unambiguously choose the same variety. As an example, although a ‘blue’ Mercedes contains more of the ‘blue’ characteristic than a ‘white’ Mercedes, not all consumers would clearly choose the ‘blue’ Mercedes. This work focuses on horizontal product differentiation.

There are two approaches to formalise horizontal product differentiation. The first, which has developed out of the Hotelling [1929] model, is referred to as the 'address' (or parametric) approach. It is assumed that goods/products can be described by their inherent characteristics and that consumers can be described by the characteristics content of their ideal products. This allows both existing products and consumers to be located in a space of characteristics (e.g., coordinates on a line). Notice that in this framework consumers' preferences are diverse and asymmetric. Each consumer possesses a clear ranking over all available products when they are offered at the same price. Moreover, it is assumed that varieties of the differentiated product cannot be combined in consumption. A fundamental consequence of assuming preference asymmetry is that competition between varieties becomes localised. Loosely interpreted, localised competition refers to a situation where not all variants of the differentiated good are substitutes. Localised competition is best visualised in a one-dimensional 'address' model: Each variant has only two neighbours and directly competes only with these two variants.

The second approach has its roots in the work of Chamberlin [1933] and is referred to as the 'non-address' approach of product differentiation. Here, it is assumed that consumers' preferences for differentiated goods are defined over a predetermined set (finite or countably infinite) of all possible goods. Under this framework, consumers have a taste for variety. In general it is assumed that consumers like all brands and that there is a representative consumer whose tastes over the various brands are symmetric. Since all varieties of the differentiated good are roughly symmetric substitutes, all varieties are in equal competition with all others. Accordingly, the 'non-address' approach implies a nonlocalised competition. This chapter exclusively deals with the 'address' approach of product differentiation and therefore with a localised competition between varieties.

Given these definitions, the analogy between product differentiation models and spatial models is straightforward. Since the 'address' approach assumes that both existing products and consumers are located in a space characteristics (e.g., the line, the plane or the circumference of a circle), 'address' models of product differentiation are usually referred to as 'spatial' or 'location' models of imperfect competition. Accordingly, the 'address' model of product differentiation can be interpreted in different ways. In a purely spatial or geographic context the characteristics space would be the distance: The differentiation between two products is measured by the distance between the two plant locations, with consumers located at particular buying points. Notice that the basic spatial model is easily transformed into a nonspatial context. Air transport scheduling provides a particularly interesting example. In the case of transport scheduling, one obvious element of product differentiation is the schedule itself. Actually, just as indivisible production units have to be given well-defined geographic locations, indivisible transportation units such as airplanes have to be given well-defined departure times. Similarly, consumers in the market for transport services have preferred

departures times, whether in the day, month, or year. Rather than the geographical distance, we now have 'time' as a characteristics space. Corresponding to the transport costs incurred by consumers not located at the plant locations, there is the waiting time and inconvenience (additional living expenses for food, hotel, or storage costs of freightage, etc.) incurred by those travellers whose desired departure time does not coincide with a scheduled airline departure<sup>2</sup>. Table 4.1 summarises the essence of the transformation of the product differentiation model into a spatial and nonspatial context, for a given market.

**Table 4.1: Analogy Between Space Location, Product Differentiation and Transport Scheduling**

<i>Spatial Location</i>	<i>Product differentiation</i>	<i>Transport Scheduling</i>
Production location	Product variety $j$	Offered departure time
Consumer location	Preferred consumer variety $i$	Preferred departure time
Distance	Characteristics space	Time
F.o.b. mill price	Price of variety $j$	Flight fare (airline ticket)
Transport cost	Loss of utility $d_{ij}$	Waiting time, inconvenience

*Source:* Greenhut et al.[1987]

In the rest of this chapter and throughout the following chapter, Chapter 5, I make use of the three different interpretations depending on the appropriate context. For example, an outlet, at a particular geographical location, can designate a flight at a particular point of the time domain.

### 4.3 The Assumptions of the Spatial Setting

Firms and consumers are located on a circle with unit circumference<sup>3</sup>. Two firms, Firm  $A$  and Firm  $B$ , operate in the market and entry by another potential firm is ruled out. Each duopolist has two potential outlets located on the circle. Outlet locations are denoted by  $x_k^i$  ( $i = 1, 2$ , and  $k = A, B$ ). Marginal production costs are constant and equal to zero (without loss of generality). The fixed cost per outlet and the sunk cost per firm are assumed to be zero for consistency with the Martinez-Giralt & Neven and Bensaid & de Palma papers. Duopolists set mill

<sup>2</sup>Douglas & Miller [1974] introduce the concept of frequency delay and stochastic delay in their analysis of air transportation. The former delay captures the inconvenience caused by taking a flight which does not depart at one's most desired departure time, while the latter delay arises when one cannot obtain a seat on the most convenient flight (because of capacity constraints). Accordingly, the frequency delay should be interpreted as the loss of utility in the traditional 'address' model of product differentiation.

<sup>3</sup>Samuelson [1967] first suggested that competition on the circumference of the circle could be interpreted as competition around a lake. In a nonspatial context, circular models can be interpreted as competition by airlines offering daily services on a given route at particular times of the day.

prices<sup>4</sup>  $p_k^i$  such that profits are maximised under (noncooperative) Nash behaviour. Products or services offered by the duopolists are homogenous except for the spatial dimension (product characteristics space). In other words, products are said to be horizontally differentiated (see Philips & Thisse [1982]). It is assumed that consumers are uniformly distributed around the circle and the population has mass  $D = 100000$ . They are identical apart from their location. Contrary to the standard Hotelling assumption that each consumer buys exactly one unit of the differentiated good, I assume that each consumer has an elastic demand<sup>5</sup>. I also assume that consumer's reservation price is finite and sufficiently small<sup>6</sup>. Each customer patronises the outlet for which the delivered price is the lowest. The delivered price is the sum of the mill price plus the utility loss incurred by not purchasing the most preferred product. In a purely spatial context, the delivered price represents the sum of the f.o.b. price and the transportation costs incurred by the customer. Since d'Aspremont's et al. 1979 paper, it is standard to assume a quadratic transportation cost function. This is one way to establish the existence of a price equilibrium in a two stage game. As stressed by Neven [1985] the quadratic utility loss seems more natural than Hotelling's [1929] original linear loss when consumers move in a characteristics space.

Following Lovell [1970], let us assume that consumer  $j$ 's utility function is

$$U_j = \left(\frac{a}{b} - c(d_{lj})^2\right)q_{lj} - \frac{(q_{lj})^2}{2b} + v_j, \quad (4.1)$$

where  $a, b, c > 0$ ,  $q_{lj}$  is the quantity of the differentiated product,  $l = x_k^i$ , and  $d_{lj}$  represents the distance between consumer  $j$  and the location of product  $l$ . In this framework,  $v_j$  is the consumption of an outside good (different from the differentiated product industry) (see Salop [1979]). Consumer  $j$ 's demand function for the differentiated product is obtained by maximising (4.1) under the budget constraint,  $Y_j = p_l q_{lj} + v_j$  where  $Y_j$  is consumer  $j$ 's revenue and the price of the outside good is the numéraire. The individual demand is then equal to

$$q_{lj} = \max[a - b(p_l + c(d_{lj})^2), 0]. \quad (4.2)$$

It is clear that each customer patronises the outlet where he obtains the maximal utility<sup>7</sup>. The reservation price is equal to  $a/b$  and characterises consumer  $j$ 's

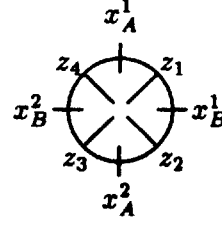
<sup>4</sup>Accordingly, it is assumed that firms do not price discriminate across consumers.

<sup>5</sup>The demand is expressed per unit of time period. The time unit can be the day, the week, the month, the year, etc. Notice that the larger the unit of time, the more likely consumers buy more than one unit of good or service. See Greenhut et al. [1987] for a general treatment of elastic demand in spatial models.

<sup>6</sup>Hotelling [1929, p.48] raises the point that with an inelastic demand, duopolists could exploit the consumers without limit. This is hardly conceivable in real world business. Notice that Hotelling [1929, p.56] himself was aware that as soon as one departs from the inelastic demand assumption, the algebra becomes complicated.

<sup>7</sup>Notice that the subscript  $j$  can be omitted since all consumers are identical except for their most preferred variety.

Figure 4.1: The Two (Interlaced) Outlets Case



highest willingness to pay for its most preferred variety (when  $d_{ij} = 0$ ). For the purpose of this note, I assume that  $a/b = \alpha$ . Consequently, the consumers' subjective valuation of the differentiated good,  $\alpha$ , is positive and finite. Moreover, assume for the sake of simplicity that the utility loss (transportation) rate,  $c$ , is equal to unity. Figure 4.1 depicts the candidate equilibria for the **interlaced** outlet location. Let  $0 \leq x_A^1 < x_B^1 < x_A^2 < x_B^2 < 1$ . Without loss of generality,  $x_A^1$  can be set to zero. Using (4.2), the consumer who is indifferent between outlets  $x_A^1$  and  $x_B^1$  has a location  $z_1$  such that the delivered prices are identical:

$$p_A^1 + (z_1 - x_A^1)^2 = p_B^1 + (x_B^1 - z_1)^2. \quad (4.3)$$

Using (4.3), the location of the marginal consumer,  $z_1(\cdot)$ , is equal to

$$z_1(\cdot) = \frac{x_A^1 + x_B^1}{2} + \frac{p_B^1 - p_A^1}{2(x_B^1 - x_A^1)}. \quad (4.4)$$

Similarly, we have that

$$z_2(\cdot) = \frac{x_B^1 + x_A^2}{2} + \frac{p_A^2 - p_B^1}{2(x_A^2 - x_B^1)}, \quad (4.5)$$

$$z_3(\cdot) = \frac{x_A^2 + x_B^2}{2} + \frac{p_B^2 - p_A^2}{2(x_B^2 - x_A^2)}, \quad (4.6)$$

$$z_4(\cdot) = \frac{1 + x_A^1 + x_B^2}{2} + \frac{p_A^1 - p_B^2}{2(1 + x_A^1 - x_B^2)}. \quad (4.7)$$

Clearly, the marginal location,  $z_l(\cdot)$  ( $l = 1, \dots, 4$ ), is a function of the prices,  $p_k^i$ , and the locations of the different outlets,  $x_k^i$ , ( $i = 1, 2$  and  $k = A, B$ ).

Given (4.2), the quantity demanded by a consumer in the interval  $ds$  located at  $s$  with  $x_A^1 = 0 \leq s \leq z_1$ ,  $dq_A^1(+)$ , is equal to

$$dq_A^1(+) = [b(\alpha - (p_A^1 + (s - x_A^1)^2))]ds, \quad (4.8)$$

and the quantity demanded by a consumer in the interval  $ds$  located at  $s$  with  $z_4 \leq s \leq 1 + x_A^1$ ,  $dq_A^1(-)$ , is equal to

$$dq_A^1(-) = [b(\alpha - (p_A^1 + (1 + x_A^1 - s)^2))]ds. \quad (4.9)$$



Consequently, the demand faced by the outlet located at  $x_A^1$ ,  $q_A^1(\cdot)$ , is obtained by the following aggregation:

$$q_A^1(\cdot) = \int_{s=0}^{s=z_1} dq_A^1(+) + \int_{s=z_4}^{s=1+x_A^1} dq_A^1(-). \quad (4.10)$$

Similarly, the demand faced by the outlets located at  $x_A^2$ ,  $x_B^1$ , and  $x_B^2$ , is

$$q_A^2(\cdot) = \int_{s=z_2}^{s=z_3} [b(\alpha - (p_A^2 + |s - x_A^2|^2))] ds, \quad (4.11)$$

$$q_B^1(\cdot) = \int_{s=z_1}^{s=z_2} [b(\alpha - (p_B^1 + |s - x_B^1|^2))] ds, \quad (4.12)$$

and

$$q_B^2(\cdot) = \int_{s=z_3}^{s=z_4} [b(\alpha - (p_B^2 + |s - x_B^2|^2))] ds, \quad (4.13)$$

respectively. The explicit evaluation of (4.10)-(4.13) can be found in the Appendix [see (4.34)-(4.37)].

Given our previous assumptions, Firm  $A$ 's profit,  $\Pi_A$ , and Firm  $B$ 's profit,  $\Pi_B$ , are

$$\Pi_A(\cdot) = D(p_A^1 q_A^1(\cdot) + p_A^2 q_A^2(\cdot)), \quad (4.14)$$

and

$$\Pi_B(\cdot) = D(p_B^1 q_B^1(\cdot) + p_B^2 q_B^2(\cdot)), \quad (4.15)$$

respectively (with  $D$  for population density).

In order to solve the above maximisation problem, two equilibrium concepts have been investigated in the literature: A **simultaneous equilibrium** where both firms choose product range-locations and prices simultaneously (see, e.g., Gabszewicz & Thisse [1986]) and a **two stage equilibrium** where both firms simultaneously choose product range-locations in a first stage and then prices in a second stage (see, e.g., Martinez-Giralt & Neven [1988]). The latter is a **two stage subgame perfect Nash equilibrium** and is more appealing on the grounds that prices are generally more flexible than locations and product range<sup>8</sup>. Moreover past research has shown that a simultaneous price-location equilibrium does not exist in these (spatial) models.

The two stage subgame perfect Nash equilibrium is obtained by first solving for the price equilibrium of the last stage of the game (holding locations fixed) and then, given the equilibrium prices, solving for the optimal locations of the first stage of the game.

---

<sup>8</sup>Clearly, if product differentiation is merely a function of small features such as colour or packaging, then it is likely that relocation of a product would be easily and cheaply completed. When product differentiation requires, e.g., extensive advertising or product redesign, then relocation is likely to be difficult and costly.

**Proposition 1** *Consider two duopolists, each owning two potential outlets. When consumers have an elastic demand as given by (4.2), with a finite and small enough reservation price,  $\alpha$ , equal to  $5/192$ , there exists a unique two stage location-then-price equilibrium. At equilibrium each firm operates the two outlets. The outlets are located symmetrically on the orthogonal diameters of the circle at 12, 3, 6 and 9 o'clock. Equilibrium prices and profits are  $\frac{1}{96}$  and  $\frac{3125}{576}b$ , respectively.*

## 4.4 Proof

### 4.4.1 The Second Stage Price Equilibrium

Since the point of this note is to show how multi-outlet equilibria can emerge within the duopoly paradigm, let us focus on symmetric equilibria only. In fact, with a small and finite reservation price, intuition calls for firms to select equidistant product locations on the orthogonal diameters of the circle, i.e., symmetric equilibria, as illustrated in Figure 4.1.

Given the profit functions (4.14)-(4.15) and aggregate demands (4.34)-(4.37) (see Appendix Section 4.7.1), the equilibrium prices of the last stage of the game are solutions of the following system<sup>9</sup>:

$$\frac{\partial \Pi_k(\theta, \cdot)}{\partial p_k^i} = 0, \quad \forall i = 1, 2 \quad k = A, B. \quad (4.16)$$

If the equilibrium locations are symmetric, so that  $\gamma = \mu \equiv \theta$ , firms set identical prices, i.e.,  $p_A^1 = p_A^2 = p_B^1 = p_B^2$ . Let us designate the (noncooperative) equilibrium prices  $p^*(\theta)$ , where by definition  $x_B^1 - x_A^1 = x_B^2 - x_A^2 = x_A^2 - x_B^1 = 1 + x_A^1 - x_B^2 = \theta$  (see Appendix). After some intricate algebraic manipulations, it can be shown that the equilibrium price,  $p^*(\theta)$ , is equal to  $\frac{1}{24}[12\alpha + 21\theta^2 - \sqrt{3}\sqrt{\delta}]$ , with  $\delta = 48\alpha^2 - 24\theta^2\alpha + 163\theta^4 > 0$ ,  $\forall \theta, \alpha > 0$ . Plugging  $p^*(\theta)$  into the profit function,  $\Pi_k(\cdot)$ , we have

$$\Pi_k(\theta, p^*(\theta)) = \frac{3125}{9}b\theta[12\alpha + 21\theta^2 - \sqrt{3}\sqrt{\delta}][12\alpha - 23\theta^2 + \sqrt{3}\sqrt{\delta}], \quad k = A, B. \quad (4.17)$$

### 4.4.2 The First Stage Location Equilibrium

The equilibrium locations of the first stage of the game are the solutions of the following system<sup>10</sup>:

$$\frac{\partial \Pi_k(\theta, p^*(\theta))}{\partial \theta} = 0, \quad \forall k = A, B. \quad (4.18)$$

<sup>9</sup>The existence of an equilibrium depends on the quasiconcavity of the profit functions (4.14)-(4.15) and hence on the concavity of the aggregate demand functions (4.34)-(4.37). In order to ensure the concavity of (4.34)-(4.37) I assume the price strategy space to be restricted to  $[0, \alpha]$ .

<sup>10</sup>The existence of equilibrium depends on the quasiconcavity of  $\Pi_k(\theta, p^*(\theta))$  in  $\theta$ .

The solution of this system yields<sup>11</sup>  $\theta^*(\alpha) = \frac{2}{5}\sqrt{3}\sqrt{5}\sqrt{\alpha}$ . Symmetric locations imply that, in equilibrium,  $\theta^* = 1/4$ . It is immediate to show that a reservation price,  $\alpha$ , equal to  $5/192$  yields  $\theta^* = 1/4$ . Therefore, as soon as  $a = (5/192)b$ , there exist a two stage location-then-price equilibrium. The equilibrium entails symmetric locations with outlets located on the orthogonal diameters of the circle at 12, 3, 6 and 9 o'clock<sup>12</sup> (see Figure 4.1).

Using the equilibrium location values, we have that  $p^* = p_A^1 = p_A^2 = p_B^1 = p_B^2 = 1/96 \cong 0.0104$ , and  $\Pi_k^* = (3125/576)b \cong 5.425b$ ,  $\forall k = A, B$ . It can be verified that the second order conditions are negative when evaluated at the optimal values. Consequently, in equilibrium, we have that the whole market (circle) is served (or covered) at mill prices equal to  $p^*$ , with the marginal consumers located at  $z^* = \tau/8$  ( $\tau = 1, 3, 5, 7$ ) paying a delivered price equal to their reservation price  $a/b = 5/192$ . In other words, a reservation price equal to  $5/192$  ensures that all consumers maximise their utility when buying the differentiated good and firms maximise their profits when charging a mill price  $p^*$  for each outlet located at  $\tau/4$ , with  $\tau = 1, 2, 3, 4$ .

It is important to note that the existence of a two stage symmetric equilibrium crucially depends on the relation between the parameters of the model. The interesting issue that then arises, is the question of the product range. Given the structure of our spatial multiproduct duopoly model, would firms be better off by producing a single outlet? In other words, does the Martinez-Giralt & Neven's [1988] 'negative' result prevail when firms face an elastic demand and consumers have a finite and small reservation price equal to  $\alpha = 5/192$ ? This question is addressed in the next section where the scope decision (or product range stage of the game) is investigated. I show that the introduction of a second outlet forms a global perfect equilibrium.

#### 4.4.3 The Scope Decision

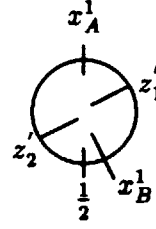
In this section, firms have to decide how many products to produce (or sell): This is the scope decision. Let us investigate a (similar) two stage game when Firm A (Firm B) contemplates to locate a single outlet at  $x_A^1$  ( $x_B^1$ ), as illustrated in Figure 4.2 (see page 130). Let us assume that  $0 \leq x_A^1 < x_B^1 \leq 1/2$ , with locations  $z_1'(\cdot)$  and  $z_2'(\cdot)$  given by

$$z_1'(\cdot) = \frac{x_A^1 + x_B^1}{2} + \frac{p_B^1 - p_A^1}{2(x_B^1 - x_A^1)}, \quad (4.19)$$

<sup>11</sup>The (economically) irrelevant roots were omitted.

<sup>12</sup>The choice of normalisation requires  $x_A^1$  to be located at 12 o'clock. Another choice of normalisation would have produced, without loss of generality, a similar equilibrium, e.g. at 13,4,7 and 10 o'clock.

Figure 4.2: The One Outlet Case



and

$$z_2'(\cdot) = \frac{1 + x_A^1 + x_B^1}{2} + \frac{p_A^1 - p_B^1}{2(1 + x_A^1 - x_B^1)}. \quad (4.20)$$

Again, without loss of generality,  $x_A^1$ , can be set to zero. The demand faced by the outlets located at  $x_A^1$  and  $x_B^1$  are given by the following expressions:

$$q_A^1(\cdot) = \int_{s=0}^{s=z_1'} [b(\alpha - (p_A^1 + (s - x_A^1)^2))] ds + \int_{s=z_2'}^{s=1+x_A^1} [b(\alpha - (p_A^1 + (1 + x_A^1 - s)^2))] ds, \quad (4.21)$$

and

$$q_B^1(\cdot) = \int_{s=z_1'}^{s=z_2'} [b(\alpha - (p_B^1 + |s - x_B^1|^2))] ds. \quad (4.22)$$

The explicit derivation of (4.21)-(4.22) can be found in Section 4.7.2 [see equations (4.40)-(4.41)]. It follows that Firm A and Firm B's profit functions are:

$$\Pi_A(\cdot) = D(p_A^1 q_A^1(\cdot)), \quad (4.23)$$

and

$$\Pi_B(\cdot) = D(p_B^1 q_B^1(\cdot)), \quad (4.24)$$

respectively.

Given the profit functions (4.23)-(4.24) and the aggregate demand functions (4.40)-(4.41), the equilibrium prices of the last stage of the game are solutions of the following system:

$$\frac{\partial \Pi_k(\lambda, \cdot)}{\partial p_k^1} = 0, \quad \forall k = A, B, \quad (4.25)$$

where  $\lambda = x_B^1 - x_A^1$  (see Appendix). In symmetric equilibrium it must be the case that firms set identical prices, i.e.,  $p_A^1 = p_B^1 = p^*(\lambda)$ . It can be shown that the equilibrium price,  $p^*(\lambda)$ , is equal to  $\frac{1}{24}[12\alpha + 21\lambda(1 - \lambda) - \sqrt{3}\sqrt{\delta_1}]$ , with  $\delta_1 = 99\lambda^4 - 198\lambda^3 + 83\lambda^2 + 16\lambda + 48\alpha^2 - 24\alpha\lambda(1 - \lambda) > 0$ ,  $\forall \alpha > 0$ , and  $\lambda$ ,  $0 \leq \lambda \leq 1/2$ . Plugging  $p^*(\lambda)$  into the profit function,  $\Pi_k(\cdot)$ , we have

$$\Pi_k(\lambda, p^*(\lambda)) = \frac{3125}{36} b [12\alpha + 21\lambda(1 - \lambda) - \sqrt{3}\sqrt{\delta_1}] [12\alpha - 2 - 15\lambda(1 - \lambda) + \sqrt{3}\sqrt{\delta_1}] \quad (4.26)$$

$\forall k = A, B$ .

The equilibrium locations of the first stage of the game are the solutions of the following system:

$$\frac{\partial \Pi_k(\lambda, p^*(\lambda))}{\partial \lambda} = 0 \quad \forall k = A, B. \quad (4.27)$$

The solution of this system yields  $\lambda^* = 1/2$ . This implies that Firm *A* and Firm *B*'s outlets are located at 12 and 6 o'clock, respectively. Therefore, a two stage subgame perfect Nash equilibrium of this game yields maximal product differentiation. Accordingly, for the one outlet case, the fact that the reservation price is finite does not alter the main result obtained with an inelastic demand: Firms try to relax price competition through maximal product differentiation<sup>13</sup> (see, e.g., Neven [1985]). Using  $\lambda^* = 1/2$ , we can express the mill prices and profits as a function of the reservation price  $\alpha$ :

$$p^* = \frac{1}{96}[48\alpha + 21 - \sqrt{3}\sqrt{163 - 96\alpha + 768\alpha^2}], \quad (4.28)$$

and

$$\Pi_k = \frac{3125}{576}b[48\alpha + 21 - \sqrt{3}\sqrt{163 - 96\alpha + 768\alpha^2}][48\alpha - 23 + \sqrt{3}\sqrt{163 - 96\alpha + 768\alpha^2}] \quad (4.29)$$

$$\forall k = A, B.$$

Finally, using  $\alpha = 5/192$ , we can evaluate (4.28) and (4.29). We have that  $p^* = (1/384)[89 - \sqrt{7729}] \cong 0.00283$ , and  $\Pi_k^* = (3125/576)b[11\sqrt{7729} - 967] \cong 0.336b$ ,  $\forall k = A, B$ .  $\square$

---

<sup>13</sup>This result holds for linear and circular market shapes.

Table 4.2: Comparison of the Equilibrium Values

	Two Outlet Case	One Outlet Case
Price	$\frac{1}{96} \cong 0.0104$	$\frac{89 - \sqrt{7729}}{384} \cong 0.0029$
Quantity Sold	$D \sum q_k^i = \frac{D}{96} b \cong 1041.6b$	$D \sum q_k^i = D \left( \frac{\sqrt{7729} - 87}{384} \right) b \cong 238.2b$
Market Coverage	100%	$\cong 60.1\%$
Profit	$\Pi_k = \frac{3125}{576} b \cong 5.425b$	$\Pi_k = \frac{3125}{576} b [11\sqrt{7729} - 967] \cong 0.336b$
Consumer Surplus (CS) <sup>◆</sup>	$\frac{3125}{768} b \cong 4.069b$	$\cong 5.475b$
Social Welfare (W) <sup>◆</sup>	$\frac{34375}{2304} b \cong 14.92b$	$\cong 6.148b$

*Notes:* <sup>◆</sup>  $CS = D \left[ \int_{p=p^*}^{p=a/b} \left( 8 \int_{s=0}^{s=1/8} (a - b[\rho + s^2]) ds \right) d\rho \right]$  in the two outlets case and  $CS = D \left[ \int_{p=p^*}^{p=a/b} \left( 4 \int_{s=0}^{s=d^*} (a - b[\rho + s^2]) ds \right) d\rho \right]$  in the one outlet case. <sup>◆</sup>  $W = \Pi_A + \Pi_B + CS$ .

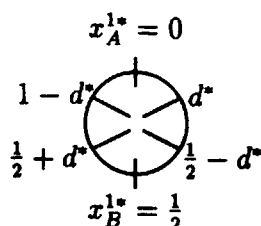
The results of this section indicate that, in the product range stage of the game, duopolists would always prefer to operate (or open) a second outlet since profits are higher in this latter case<sup>14</sup> ( $5.425b > 0.336b$ ). Hence, when consumers' reservation price is finite and small enough, the multi-outlet equilibrium emerges as a global equilibrium. For the sake of clarity, Table 4.2 reports the key values for the one outlet and two outlet cases. It is interesting to note that it is socially optimal to produce a larger number of differentiated goods. The extra profits obtained by the producers outweigh the loss in consumer surplus<sup>15</sup>.

What are the forces that drive this result? In the Martinez-Giralt & Neven's [1988] paper two opposing forces are at work when duopolists contemplate the introduction of a second outlet. On the one hand, there is a positive effect on profits due to the increase of the market share (better coverage of the product characteristics space). On the other hand, there is a negative price effect due to the increase in price competition between more nearby outlets. Matters are quite different with an elastic demand and a "binding" reservation price. The price effect turns out to be **positive**: The introduction of a second outlet allows duopolists to charge a higher mill price ( $1/96 > (1/384)[89 - \sqrt{7729}]$ ). With two outlets, each outlet serves a smaller market area so that the f.o.b. mill price can be higher than when only one outlet has to serve a larger market area, given the reservation price  $\alpha = 5/192$ . This price effect reinforces the market share effect of adding a second product (or shop).

<sup>14</sup>In fact, this is true as long as sunk costs or fixed costs are not too large.

<sup>15</sup>When consumers are not the owners of the firms, this result suggests that distributional effects could become an important issue.

Figure 4.3: Equilibrium in the One Outlet Case



Notice that in the two outlet case, each firm covers exactly half the (circular) market, whereas in the one outlet case, it is profit maximising to cover only some 30% of the market. In this latter case, it is straightforward to show that a consumer located at a distance  $d^* = \sqrt{(\sqrt{7729} - 79)/384} \cong 0.1524$  from the nearest outlet, faces a delivered price which equals its reservation price. This is illustrated in Figure 4.3. This result suggests that some consumers can't afford buying the differentiated good in the one outlet case.

To give more insight into this result, consider the following (nonspatial) example. A passenger living on Eden Island has planned a trip to Beauty Island and its most preferred departure day is Wednesday. Suppose that only two weekly flights are operated on this route. These flights are identical in all dimensions except that Airline A operates a Monday flight, and Airline B operates a Saturday flight. As a result, if the passenger decides to travel, he would incur a monetary penalty (utility loss) whatever option he chooses. This penalty includes additional living expenses for food, hotel, etc., due to time inconvenience. The results of this chapter suggest that, with a sufficiently small reservation price, the passenger may have to cancel his travel simply because there are no additional more convenient flights available. If Airline A had also operated a Tuesday flight and Airline B had operated a Thursday flight, he would have gone to Beauty Island.

## 4.5 Conclusion

A spatial (circular) model is used to endogenously determine the number of products sold by a duopoly and their locations in the characteristics space. An example shows how multiproduct equilibria emerge when firms face a "binding" reservation price, i.e, when consumers have an elastic demand with a finite and small (enough) reservation price. Clearly, this rather general condition is likely to hold for a broad class of differentiated goods. I show that a subgame perfect equilibrium (of a two stage game) requires each firm to open two outlets on the orthogonal diameter of the circle. This equilibrium allows firms to obtain a greater profit than with a single outlet, because both the price effect and the market share (or segmentation) effect are positive. Moreover, I show that the

introduction of the second outlet is socially desirable. These results depart from the previous literature. Notice that similar results are likely to emerge under a neighbouring outlet location, i.e., when  $0 \leq x_A^1 < x_A^2 < x_B^1 < x_B^2 < 1$ . In this latter case, firms have no incentive to relax price competition by clustering their two 'neighbouring' outlets in a single point. This arises because they would lose some market coverage and would have to charge a lower equilibrium price, *ceteris paribus*.

The results were obtained with a (standard) quadratic utility loss function. Intuition suggests that more 'convex' utility loss functions would provide qualitatively similar results.

Although the demand side of the spatial models is, in general, fairly well specified, one has to recognise that the cost side is typically neglected (even if many results can be obtained, without loss of generality, by setting the marginal costs to zero). Issues such as capacity constraints (e.g., in the case of an aircraft) or economies of scope could be added to provide more insight on spatial multiproduct oligopoly models. By the same token, non uniform demand and/or demand uncertainty could play a role for product diversification and therefore such ingredients could enrich the analysis of spatial multiproduct models. These would be interesting, but definitively difficult, research topics.

## 4.6 References

- BENSAID, B., and de PALMA, A., 1994, "Spatial Multiproduct Oligopoly," Working Paper No. 1994.8, University of Geneva, April.
- d'ASPREMONT, C., GABSZEWICZ, J.J., and THISSE, J.-F., 1979, "On Hotelling's Stability in Competition," *Econometrica*, 47, pp.1145-50.
- CHAMBERLIN, E.H., 1933, *The Theory of Monopolistic Competition*, Cambridge: Harvard University Press.
- DOUGLAS, G.W., and MILLER, J.C., 1974, *Economic Regulation of Domestic Air Transport: Theory and Policy*, Brookings Institution, Washington D.C.
- GABSZEWICZ, J.J., and THISSE, J.-F., 1986, "Spatial Competition and the Location of Firms," in Gabszewicz, Thisse, M. Fujita and U. Schweizer, *Location Theory, Fundamentals of Pure and Applied Economics* (eds), Hardwood Academic Publishers, Chur (Switzerland).
- GREENHUT, M.L., NORMAN, G., and HUNG, C.-S., 1987, *The Economics of Imperfect Competition: A Spatial Approach*, Cambridge University Press.



- HOTELLING, H.**, 1929, "Stability in Competition," *Economic Journal*, 39, pp.41-57.
- LOVELL, M.C.**, 1970, "Product Differentiation and Market Structure," *Western Economic Journal*, 8, pp.120-143.
- MARTINEZ-GIRALT, X.**, and **NEVEN, D.**, 1988, "Can Price Competition Dominate Market Segmentation ?," *The Journal of Industrial Economics*, 36, pp.431-442.
- NEVEN, D.**, 1985, "Two Stage (Perfect) Equilibrium in Hotelling's Model," *The Journal of Industrial Economics*, 33, pp.317-325.
- PEITZ, M.**, 1995, "The Circular Road Revisited," Working Paper No. A-471, University of Bonn, February.
- PHILIPS, L.**, and **THISSE, J.-F.**, 1982, "Spatial Competition and the Theory of Differentiated Markets: An Introduction," *The Journal of Industrial Economics*, 31, pp.1-9.
- SALOP, S.C.**, 1979, "Monopolistic Competition with Outside Goods," *Bell Journal of Economics*, 10, pp.141-156.
- SAMUELSON, P.A.**, 1967, "The Monopolistic Competition Revolution," in R.E. Kuenne eds, *Monopolistic Competition Theory: Studies in Impact*, Essays in Honour of Edward H. Chamberlin, New York 1967, S. 105-138.

## 4.7 Appendix

### 4.7.1 The Two Outlet Case

Given the assumptions and the specifications of the circular model developed in Section 4.3, the aggregate demand functions (4.10)-(4.13) are

$$q_A^1(\cdot) = b\left\{(\alpha - p_A^1)(z_1 + 1 - z_4) - \frac{1}{3}\left((z_1 - x_A^1)^3 + (1 + x_A^1 - z_4)^3\right)\right\}, \quad (4.30)$$

$$q_A^2(\cdot) = b\left\{(\alpha - p_A^2)(z_3 - z_2) - \frac{1}{3}\left((z_3 - x_A^2)^3 + (x_A^2 - z_2)^3\right)\right\}, \quad (4.31)$$

$$q_B^1(\cdot) = b\left\{(\alpha - p_B^1)(z_2 - z_1) - \frac{1}{3}\left((z_2 - x_B^1)^3 + (x_B^1 - z_1)^3\right)\right\}, \quad (4.32)$$

$$q_B^2(\cdot) = b\left\{(\alpha - p_B^2)(z_4 - z_3) - \frac{1}{3}\left((z_4 - x_B^2)^3 + (x_B^2 - z_3)^3\right)\right\}, \quad (4.33)$$

Using (4.4)-(4.7), we can rewrite the above equations in the following way:

$$q_A^1(\cdot) = b\left\{(\alpha - p_A^1)\left(\frac{p_B^1 - p_A^1}{2\lambda_1} + \frac{p_B^2 - p_A^1}{2\lambda_4} + \frac{\lambda_1 + \lambda_4}{2}\right) - \frac{1}{3}\left(\left(\frac{p_B^1 - p_A^1}{2\lambda_1} + \frac{\lambda_1}{2}\right)^3 + \left(\frac{p_B^2 - p_A^1}{2\lambda_4} + \frac{\lambda_4}{2}\right)^3\right)\right\}, \quad (4.34)$$

$$q_A^2(\cdot) = b\left\{(\alpha - p_A^2)\left(\frac{p_B^2 - p_A^2}{2\lambda_2} + \frac{p_B^1 - p_A^2}{2\lambda_3} + \frac{\lambda_2 + \lambda_3}{2}\right) - \frac{1}{3}\left(\left(\frac{p_B^1 - p_A^2}{2\lambda_3} + \frac{\lambda_3}{2}\right)^3 + \left(\frac{p_B^2 - p_A^2}{2\lambda_2} + \frac{\lambda_2}{2}\right)^3\right)\right\}, \quad (4.35)$$

$$q_B^1(\cdot) = b\left\{(\alpha - p_B^1)\left(\frac{p_A^2 - p_B^1}{2\lambda_3} + \frac{p_A^1 - p_B^1}{2\lambda_1} + \frac{\lambda_1 + \lambda_3}{2}\right) - \frac{1}{3}\left(\left(\frac{p_A^1 - p_B^1}{2\lambda_1} + \frac{\lambda_1}{2}\right)^3 + \left(\frac{p_A^2 - p_B^1}{2\lambda_3} + \frac{\lambda_3}{2}\right)^3\right)\right\}, \quad (4.36)$$

$$q_B^2(\cdot) = b\left\{(\alpha - p_B^2)\left(\frac{p_A^1 - p_B^2}{2\lambda_4} + \frac{p_A^2 - p_B^2}{2\lambda_2} + \frac{\lambda_2 + \lambda_4}{2}\right) - \frac{1}{3}\left(\left(\frac{p_A^1 - p_B^2}{2\lambda_4} + \frac{\lambda_4}{2}\right)^3 + \left(\frac{p_A^2 - p_B^2}{2\lambda_2} + \frac{\lambda_2}{2}\right)^3\right)\right\}, \quad (4.37)$$

with  $\lambda_1 = x_B^1 - x_A^1$ ,  $\lambda_2 = x_B^2 - x_A^2$ ,  $\lambda_3 = x_A^2 - x_B^1$ , and  $\lambda_4 = 1 + x_A^1 - x_B^2$ . Clearly,  $\sum_{i=1}^4 \lambda_i = 1$ . By definition, under **quasi-symmetric** locations we have that  $\lambda_1 = \lambda_2 = \gamma$  and  $\lambda_3 = \lambda_4 = \mu$ , whereas under **symmetric** locations,  $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \theta$ . Therefore, symmetric locations are a special case of quasi-symmetric locations. Notice that, under quasi-symmetric locations we have that  $2\gamma + 2\mu = 1$  or  $\gamma = 1/2 - \mu$ .

#### 4.7.2 The One Outlet Case

Given the assumptions of Section 4.3 and Section 4.4.3, the aggregate demand functions (4.21)-(4.22) are

$$q_A^1(\cdot) = b\left\{(\alpha - p_A^1)(z_1' + 1 - z_4') - \frac{1}{3}\left((z_1' - x_A^1)^3 + (1 + x_A^1 - z_4')^3\right)\right\}, \quad (4.38)$$

and

$$q_B^1(\cdot) = b\left\{(\alpha - p_B^1)(z_2' - z_1') - \frac{1}{3}\left((z_2' - x_B^1)^3 + (x_B^1 - z_1')^3\right)\right\}, \quad (4.39)$$

respectively. Using (4.19)-(4.20), the above equations become:

$$q_A^1(\cdot) = b\left\{(\alpha - p_A^1)\left(\frac{p_B^1 - p_A^1}{2\lambda} + \frac{p_B^1 - p_A^1}{2(1-\lambda)} + \frac{1}{2}\right) - \frac{1}{3}\left(\left(\frac{p_B^1 - p_A^1}{2\lambda} + \frac{\lambda}{2}\right)^3 + \left(\frac{p_B^1 - p_A^1}{2(1-\lambda)} + \frac{1-\lambda}{2}\right)^3\right)\right\}, \quad (4.40)$$

$$q_B^1(\cdot) = b\left\{(\alpha - p_B^1)\left(\frac{p_A^1 - p_B^1}{2(1-\lambda)} + \frac{p_A^1 - p_B^1}{2\lambda} + \frac{1}{2}\right) - \frac{1}{3}\left(\left(\frac{p_A^1 - p_B^1}{2\lambda} + \frac{\lambda}{2}\right)^3 + \left(\frac{p_A^1 - p_B^1}{2(1-\lambda)} + \frac{1-\lambda}{2}\right)^3\right)\right\}, \quad (4.41)$$

with  $\lambda = x_B^1 - x_A^1$  and  $1 - \lambda = 1 + x_A^1 - x_B^1$ .

# Chapter 5

## Spatial Multiproduct Pricing: Theory and Empirical Evidence on the Intra-European Duopoly Airline Markets

*“On ne fait point de l’industrie entre ciel et terre; il faut se poser quelque part sur le sol.”*

*L. Walras [1874], Éléments d’Economie Politique Pure.*

### 5.1 Introduction

Leon Walras was indeed right. A firm or an industry must be located somewhere in geographical space if it is to assemble inputs and reach consumers. Although Leon Walras could not foresee the Wright brothers’ flight of 1903 and the subsequent development of the airspace industry throughout the century, his quotation describes the essence of the air transportation industry, the industry of interest in this work. An airline market requires well-defined geographic coordinates in the space domain and likewise, a scheduled airplane requires a well-defined departure time in the time domain. In airline markets, single product firms operating under perfect competition are rare. Actually, the airline industry, and modern businesses in general, show that multiproduct firms tend to compete among few rivals: Duopolists, each operating several flights, is a typical airline market structure. Since each flight has a well-defined location or ‘address’, a market is characterised by a particular location pattern of flights<sup>1</sup>. The aim of this chapter is to study the theoretical and empirical implications of location patterns in a spatial multiproduct duopoly model.

..

---

<sup>1</sup>See Chapter 4, in particular Section 4.2, for the analogy between space location, product differentiation and transport scheduling.

The first goal of this chapter is to address the following question: To what extent does a particular location pattern affect market power and social welfare in a spatial multiproduct duopoly. This question is addressed within the traditional framework developed by Hotelling's [1929] paper on spatial competition. The recent paper by Bensaid & de Palma [1994], first shows that different organisational structures may theoretically arise: A neighbouring location, an interlaced location and a mixed location pattern. In this work I show that a neighbouring location pattern yields less competitive prices both in the two-outlet and three-outlet cases. I demonstrate that for the two-outlet case, social welfare is not affected by location patterns while in the three-outlet case, social welfare is unambiguously higher under interlaced locations. I also show that from a social welfare point of view it is preferable to have three outlets (rather than two).

The second goal of the chapter is to empirically test for the location pattern effect on intra-European airline duopoly markets. As I emphasised in Chapter 1, despite the current phase of liberalisation in Europe (Third Package), a large number of intra-EU routes are served by only two airlines, most of the time the flag-carriers, indicating that duopoly is still the dominant market structure in the intra-EU airline market industry. This unique market structure leads to a number of reasonable simplifications which in turn allow me to test the implications of location patterns (one important aspect of the organisational structure of airline markets) on pricing behaviour (market conduct). The empirical results support the theoretical model since I find that fares are higher on intra-European markets which exhibit a neighbouring location pattern in the time domain: In accordance with intuition, price competition is reduced when each airline operates on a specific (specialised) segment of the timetable (e.g., the first 12 hours of the day). Clearly, this result has several implications for policy makers and/or airport authorities in charge of awarding slots. The message of this chapter is that there is a potential for the neighbouring pattern to be a source of market power in the air transportation industry. Additionally, I find that, on average, European airlines price discriminate according to the income of origin. These original results constitute the main empirical contribution of the chapter.

This chapter has two parts and is organised as follows. In the first part, I study the theoretical implications of the different location patterns on multiproduct duopoly pricing, market performance and social welfare. Section 5.2 presents the spatial multiproduct duopoly setting. Contrary to the precedent chapter, it is assumed that locations are given and that consumers buy exactly one unit of the product (or service). The results of price competition are derived in Section 5.3 and Section 5.4, for the two-outlet and three-outlet cases, respectively. In the second part, I test the predictions of spatial multiproduct duopoly pricing using data on intra-European airline markets. In Section 5.5, I consider a model for comparing prices across intra-European duopoly airline markets with different location patterns. Data and the econometric specifications are discussed in Section 5.5.3. Section 5.5.4 presents and interprets the empirical findings. Finally, Section 5.6 concludes.

## 5.2 Price Competition and Location Choice in Multiproduct Duopoly

This section provides the general framework for the analysis of spatial multiproduct duopoly. The notation and terminology borrow heavily from Bensaid & de Palma's [1994].

Firms and consumers are located on a circle with unit circumference ( $L = 1$ ). In a nonspatial context, the length of the circle could be 18 hours (from 6 am to 12 pm). Two firms, Firm *A* and Firm *B*, operate in the market, and entry by another potential firm is ruled out. Each multiproduct duopolist provides  $n$  ( $n \geq 2$ ) outlets distributed on the circle with outlet locations denoted by  $x_k$  ( $k = 1, \dots, 2n$ ) with  $0 \leq x_1 \leq \dots \leq x_k \leq \dots \leq x_{2n} \leq 1$ . Firm *A*'s (Firm *B*'s) marginal production cost are assumed to be constant and equal to  $c_A$  ( $c_B$ ). The fixed cost per outlet and the sunk cost per firm are assumed to be zero. Duopolists set mill prices<sup>2</sup>  $p_k$  ( $k = 1, \dots, 2n$ ) such that profits are maximised under noncooperative Nash behaviour. Products or services offered by the duopolists are homogenous except for the spatial dimension. In a nonspatial context, one can think of services differentiated in the time dimension. It is assumed that consumers are uniformly distributed around the circle and the population has mass  $D$ . They are identical apart from their location. Each consumer buys exactly one unit of the product (or service) so that total market demand is inelastic. It is assumed that consumers' reservation prices are sufficiently large so that consumers always buy the product. Each customer patronises the outlet for which the delivered price is the lowest. The delivered price is the sum of the mill price plus the utility loss incurred by not purchasing at the most preferred outlet. In a purely spatial context, the delivered price represents the sum of the f.o.b mill price and the transportation costs incurred by the customer. It is assumed that the indirect utility function of a consumer located at  $x$  and purchasing good  $k$  is  $v_k = y - p_k - \delta(x_k - x)^2$ , where  $y$  represents the income of the consumer and  $\delta > 0$  is the utility loss (transportation) rate. In other words, the farther a customer is located from its ideal outlet the larger the delivered price and utility loss. Clearly, each customer patronises the outlet where he obtains the maximal utility.

Let us assume that  $x_{2n+1} = x_1$  and that  $x_k < x_{k+1}$ . The consumer who is indifferent between outlet  $k$  and  $k + 1$  has a location  $z_k$  such that:

$$y - p_k - \delta(z_k - x_k)^2 = y - p_{k+1} - \delta(z_k - x_{k+1})^2. \quad (5.1)$$

Using (5.1), the location of the marginal consumer,  $z_k(\cdot)$ , is equal to

$$z_k = \frac{x_k + x_{k+1}}{2} + \frac{p_{k+1} - p_k}{2\delta(x_{k+1} - x_k)}, \quad k = 1, \dots, 2n. \quad (5.2)$$

---

<sup>2</sup> Accordingly, it is assumed that firms do not price discriminate across consumers.

By convention  $z_0 = z_{2n} - 1$ . Given (5.2) we can derive the market shares  $S_k(\cdot)$  and therefore the demand for each outlet  $k$ . Clearly, the market shares will be a function of (a) the vector of locations  $x = (x_1, \dots, x_{2n})$  and (b) the vector of prices  $p = (p_1, \dots, p_{2n})$ . The market shares  $S_k(x, p)$  of outlet  $k$  is simply given by the following expression:

$$S_k(x, p) = z_k - z_{k-1}, \quad k = 1, \dots, 2n. \quad (5.3)$$

Assume that Firm  $A$  owns every outlet  $k \in K_A$  with  $K_A \cup K_B = \{1, \dots, 2n\}$ . Given the assumptions on the fixed and sunk costs, Firm  $A$ 's profit is:

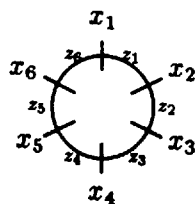
$$\Pi_A(x, p) = D \left( \sum_{k \in K_A} (p_k - c_A) S_k(x, p) \right). \quad (5.4)$$

Similarly, Firm  $B$ 's profit is:

$$\Pi_B(x, p) = D \left( \sum_{k \in K_B} (p_k - c_B) S_k(x, p) \right). \quad (5.5)$$

In order to solve the above multiproduct maximisation problem, two equilibrium concepts have been investigated in the literature: A **simultaneous equilibrium** where both firms choose product range-locations and prices simultaneously (Gabszewicz & Thisse [1986]) and a **two stage equilibrium** where both firms simultaneously choose product range-locations and then prices in a second stage (see e.g., Martinez-Giralt & Neven [1988]). The latter is called a **two stage subgame perfect Nash equilibrium**. Past research has shown that neither the simultaneous price-location equilibrium nor the two stage equilibrium exist within the above duopoly framework. In particular, Martinez-Giralt & Neven [1988] show that in the two stage duopoly model, firms always have an incentive to sell (or produce) a single (maximally differentiated) product at equilibrium. This is because, when a firm adds a second product, two contrasting effects are at work. On the one hand, the introduction of a second product allows the firm to increase its market share (market segmentation). On the other hand, it increases price competition. Martinez-Giralt & Neven [1988] show that the negative price effect outweighs the positive market share effect. In Chapter 4, I show that when duopolists face a 'binding' reservation price, i.e., when consumers have an elastic (downward sloping) demand and a finite and small reservation price, a multiproduct equilibrium may emerge as the result of a two stage game. This is because, contrary to the Martinez-Giralt & Neven's [1988] result, the price effect turns out to be positive: The introduction of a second product allows duopolists to charge a higher mill price. Using a framework similar to Martinez-Giralt & Neven [1988], Bensaid & de Palma [1994] demonstrate that as soon as three or more firms compete in the market, multiproduct equilibria emerge. This occurs because a single product firm always has an incentive to introduce a second product when it faces two or more competing firms.

Figure 5.1: Symmetric Locations in the Three Outlet Case



When duopolists are assumed to provide more than one outlet, several location patterns may theoretically arise. Using Bensaid & de Palma's [1994] terminology, I define the following three different types of location equilibria: An **interlaced** outlet equilibrium, a **neighbouring** outlet equilibrium and a **mixed** outlet equilibrium. For example, let us assume that every firm owns  $n = 3$  outlets, as illustrated in Figure 5.1. An interlaced outlet equilibrium occurs when outlets' identity (ownership) alternates. This arises when Firm A owns every outlet  $k \in K_A = \{1, 3, 5\}$  and Firm B owns every outlet  $k \in K_B = \{2, 4, 6\}$ . In this type of location it is as if each firm wishes to offer a 'product line' as broad as possible. A neighbouring outlet pattern characterises an equilibrium with all the outlets owned by a firm located next to each other. Then Firm A owns every outlet  $k \in K_A = \{1, 2, 3\}$  and Firm B owns every outlet  $k \in K_B = \{4, 5, 6\}$ . Here each firm wishes to specialise on a segment of the 'product line'. Finally, a mixed outlet pattern combines the interlaced and neighbouring equilibria. A mixed outlet equilibrium may occur, e.g, when Firm A owns every outlet  $k \in K_A = \{1, 2, 5\}$  and Firm B owns every outlet  $k \in K_B = \{3, 4, 6\}$ .

In conclusion, when one departs from the Hotelling's [1929] original assumptions, multiproduct equilibria are likely to emerge in models of spatial competition. Besides oligopolistic competition (see Bensaid & de Palma [1994]) and elasticity of the demand (see Chapter 4), additional features such as capacity constraints or economies of scope may provide more insight into spatial multiproduct competition. Unfortunately, as stressed by Greenhut et al.[1987], 'one of the major problems in the analysis of spatial competition is that a slight increase in model complexity can generate an intractable increase in mathematical complexity'. This is particularly true of any attempt to investigate the interactions between price competition and location choices among multiproduct firms. As a result, the analysis in this chapter is confined to price competition under multiproduct duopoly. This implies that product selection in the first stage of the game is assumed to be given. Firms do not choose their locations but rather are automatically located equidistant from one another on the circle<sup>3</sup>. One can argue that the assumption of exogenously given locations is rather restrictive on the grounds

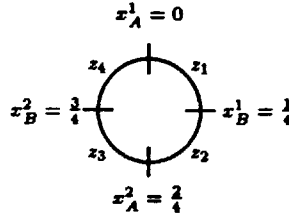
<sup>3</sup>Tirole [1988] refers to the auctioneer picking the symmetric location pattern.

that firms generally control both price and product selection (location) variables. However, for some (differentiated) industries, like air transportation, where the selection of a particular location can be interpreted as the offered departure time, it stands to reason that firms do not always control the location or schedule variable: Once the slots are allocated, they cannot be shifted (at least not without cost). This is like having an infinite sunk cost to change location. For industries where the schedule -and the frequency of service- is the main element of differentiation, I believe that this simplification is not unrealistic, at least in the short run. In the case of intra-European airline markets, for example, the choice of the offered departure time greatly depends on local airport authorities which allocate available slots (see Section 5.5.1 for further details on the airline industry). From a modelling point of view, this simplification allows us to derive useful results which can subsequently be tested in an econometric model.

In summary, the focus of this chapter is, in a first attempt, to study the theoretical implications of different location patterns on pricing, market performance and social welfare. In a second attempt, I test the predictions of spatial multiproduct pricing using data on intra-European duopoly airline markets. In the next two sections I derive the theoretical results for different location patterns. For the sake of the analysis, I focus on two important cases: The two-outlet case (Section 5.3) and the three-outlet case (Section 5.4). The results are summarised in Proposition 1 and Proposition 2. Although the analysis of the two cases is quite similar, I derive the results separately in order to provide an interesting comparison. The results of this comparison are summarised in Proposition 3.



Figure 5.2: Interlaced Locations with two Outlets



## 5.3 Spatial Multiproduct Duopoly Pricing: The Two-Outlet Case

**Proposition 1** *Consider two duopolists, each owning two outlets. Locations are exogenously given. Two different symmetric location patterns are analysed: (1) An interlaced outlet equilibrium and (2) a neighbouring outlet equilibrium. Given the location pattern and the assumptions of Section 5.2, the noncooperative Nash prices are larger in a neighbouring outlet equilibrium. As a result, market performance (profit) is larger with neighbouring outlets. Social welfare, however, is identical under both location patterns.*

### 5.3.1 The Interlaced Outlet Equilibrium

For the ease of notation let outlet locations and mill prices be given by  $x_k^i$  and  $p_k^i$ , respectively (with  $i = 1, 2$  and  $k = A, B$ ). Figure 5.2 depicts the candidate (symmetric) equilibria for the interlaced outlet location. Without loss of generality,  $x_A^1$  can be set to zero by choice of normalisation. Using (5.2), the locations of the marginal consumer,  $z_l(\cdot)$  ( $l = 1, \dots, 4$ ), are

$$z_1(\cdot) = \frac{1}{8} + \frac{2}{\delta}(p_B^1 - p_A^1), \quad (5.6)$$

$$z_2(\cdot) = \frac{3}{8} + \frac{2}{\delta}(p_A^2 - p_B^1), \quad (5.7)$$

$$z_3(\cdot) = \frac{5}{8} + \frac{2}{\delta}(p_B^2 - p_A^2), \quad (5.8)$$

$$z_4(\cdot) = \frac{7}{8} + \frac{2}{\delta}(p_A^1 - p_B^2). \quad (5.9)$$

Given (5.6)-(5.9) we derive the market shares  $S_k^i(\cdot)$  for each outlet. Notice that under the assumption of unitary (inelastic) demand there is a one to one mapping between the market shares and the aggregate demand. Market shares,  $S_k^i(\cdot)$ , are

$$S_A^1(\cdot) = z_1 + 1 - z_4 = \frac{1}{4} - \frac{4}{\delta}p_A^1 + \frac{2}{\delta}(p_B^1 + p_B^2), \quad (5.10)$$

$$S_B^1(\cdot) = z_2 - z_1 = \frac{1}{4} - \frac{4}{\delta}p_B^1 + \frac{2}{\delta}(p_A^1 + p_A^2), \quad (5.11)$$

$$S_A^2(\cdot) = z_3 - z_2 = \frac{1}{4} - \frac{4}{\delta}p_A^2 + \frac{2}{\delta}(p_B^1 + p_B^2), \quad (5.12)$$

$$S_B^2(\cdot) = z_4 - z_3 = \frac{1}{4} - \frac{4}{\delta}p_B^2 + \frac{2}{\delta}(p_A^1 + p_A^2). \quad (5.13)$$

In this set-up, Firm  $A$ 's and Firm  $B$ 's profits are

$$\Pi_A^I(\cdot) = D \left( \sum_{i=1}^{i=2} (p_A^i - c_A) S_A^i(\cdot) \right), \quad (5.14)$$

and

$$\Pi_B^I(\cdot) = D \left( \sum_{i=1}^{i=2} (p_B^i - c_B) S_B^i(\cdot) \right), \quad (5.15)$$

respectively, where the subscript ' $I$ ' stands for interlaced locations. The noncooperative Nash prices are solutions of the system of first order conditions given by<sup>4</sup>:

$$\frac{\partial \Pi_k^I(\cdot)}{\partial p_k^i} = 0 \quad i = 1, 2 \quad k = A, B. \quad (5.16)$$

The solution of the above system yields the following equilibrium prices:

$$p_A^{1*} = p_A^{2*} = \frac{1}{16}\delta + \frac{1}{3}(c_B + 2c_A), \quad (5.17)$$

$$p_B^{1*} = p_B^{2*} = \frac{1}{16}\delta + \frac{1}{3}(c_A + 2c_B). \quad (5.18)$$

The equilibrium prices are an increasing function of the marginal costs. Notice that the higher the transportation rate  $\delta$ , the higher the Nash prices. The latter results from the combination of f.o.b. mill pricing and totally inelastic demand, so that consumers accept any price. Furthermore, note that when marginal costs are identical,  $c_A = c_B = c$ , the price-cost margin is equal to  $\delta/16$ . Plugging the Nash prices (5.17)-(5.18) into the market boundaries (5.6)-(5.9), we can evaluate the market shares (5.10)-(5.13):

$$\begin{aligned} z_1^* &= \frac{1}{8} + \frac{2(c_B - c_A)}{3\delta}, \quad z_2^* = \frac{3}{8} + \frac{2(c_A - c_B)}{3\delta}, \\ z_3^* &= \frac{5}{8} + \frac{2(c_B - c_A)}{3\delta}, \quad z_4^* = \frac{7}{8} + \frac{2(c_A - c_B)}{3\delta}. \end{aligned}$$

and

$$\begin{aligned} S_A^{i*} &= \frac{1}{4} + \frac{4(c_B - c_A)}{3\delta}, \quad i = 1, 2 \\ S_B^{i*} &= \frac{1}{4} + \frac{4(c_A - c_B)}{3\delta} \quad i = 1, 2. \end{aligned}$$

Finally, after the appropriate substitutions, the profit functions (5.14)-(5.15) are equal to

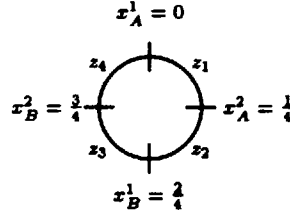
$$\begin{aligned} \Pi_A^I &= \frac{D}{288\delta} [16(c_A - c_B) - 3\delta]^2, \\ \Pi_B^I &= \frac{D}{288\delta} [16(c_A - c_B) + 3\delta]^2. \end{aligned}$$

When marginal costs are equal, we have that  $\Pi_A^I = \Pi_B^I = \frac{1}{32}D\delta$ .

---

<sup>4</sup>The existence of equilibrium depends on the quasiconcavity of the profit functions (5.14)-(5.15) and hence on the concavity of the demand functions (5.10)-(5.13). Since these latter are linear in prices, the existence is guaranteed.

Figure 5.3: Neighbouring Locations with two Outlets



### 5.3.2 The Neighbouring Outlet Equilibrium

Figure 5.3 depicts the candidate (symmetric) equilibria for the neighbouring outlet location. The main difference with the previous case is that now each firm has outlets that are no longer isolated from each other. In an interlaced equilibrium, the price in each outlet is the same as if each were operated by a single firm. Here, the equilibrium is likely to be different. Using (5.2), the locations of the marginal consumer,  $z_l(\cdot)$  ( $l = 1, \dots, 4$ ), are

$$z_1(\cdot) = \frac{1}{8} + \frac{2}{\delta}(p_A^2 - p_A^1), \quad (5.19)$$

$$z_2(\cdot) = \frac{3}{8} + \frac{2}{\delta}(p_B^1 - p_A^2), \quad (5.20)$$

$$z_3(\cdot) = \frac{5}{8} + \frac{2}{\delta}(p_B^2 - p_B^1), \quad (5.21)$$

$$z_4(\cdot) = \frac{7}{8} + \frac{2}{\delta}(p_A^1 - p_B^2). \quad (5.22)$$

Given (5.19)-(5.22) the market shares  $S_k^i(\cdot)$  for each outlet are

$$S_A^1(\cdot) = z_1 + 1 - z_4 = \frac{1}{4} - \frac{4}{\delta}p_A^1 + \frac{2}{\delta}(p_A^2 + p_B^2), \quad (5.23)$$

$$S_A^2(\cdot) = z_2 - z_1 = \frac{1}{4} - \frac{4}{\delta}p_A^2 + \frac{2}{\delta}(p_A^1 + p_B^1), \quad (5.24)$$

$$S_B^1(\cdot) = z_3 - z_2 = \frac{1}{4} - \frac{4}{\delta}p_B^1 + \frac{2}{\delta}(p_A^2 + p_B^2), \quad (5.25)$$

$$S_B^2(\cdot) = z_4 - z_3 = \frac{1}{4} - \frac{4}{\delta}p_B^2 + \frac{2}{\delta}(p_A^1 + p_B^1). \quad (5.26)$$

Firm A's and Firm B's profits with two neighbouring outlets are

$$\Pi_A^N(\cdot) = D\left(\sum_{i=1}^{i=2}(p_A^i - c_A)S_A^i(\cdot)\right), \quad (5.27)$$

and

$$\Pi_B^N(\cdot) = D\left(\sum_{i=1}^{i=2}(p_B^i - c_B)S_B^i(\cdot)\right), \quad (5.28)$$

respectively, where the subscript 'N' stands for neighbouring locations. The non-cooperative Nash prices are solutions of the system of first order conditions given

by:

$$\frac{\partial \Pi_k^N(\cdot)}{\partial p_k^i} = 0 \quad i = 1, 2 \quad k = A, B. \quad (5.29)$$

The solution of the above system yields the following equilibrium prices:

$$p_A^{1*} = p_A^{2*} = \frac{1}{8}\delta + \frac{1}{3}(c_B + 2c_A), \quad (5.30)$$

$$p_B^{1*} = p_B^{2*} = \frac{1}{8}\delta + \frac{1}{3}(c_A + 2c_B). \quad (5.31)$$

Plugging the Nash prices (5.30)-(5.31) into the market boundaries (5.19)-(5.22), we can evaluate the market shares (5.23)-(5.26):

$$z_1^* = \frac{1}{8}, z_2^* = \frac{3}{8} + \frac{2(c_B - c_A)}{3\delta},$$

$$z_3^* = \frac{5}{8}, z_4^* = \frac{7}{8} + \frac{2(c_A - c_B)}{3\delta}.$$

and

$$S_A^{i*} = \frac{1}{4} + \frac{2(c_B - c_A)}{3\delta}, \quad i = 1, 2$$

$$S_B^{i*} = \frac{1}{4} + \frac{2(c_A - c_B)}{3\delta} \quad i = 1, 2.$$

Finally, after the appropriate substitutions, the profit functions (5.27)-(5.28) are equal to

$$\Pi_A^N = \frac{D}{144\delta} [8(c_B - c_A) + 3\delta]^2,$$

$$\Pi_B^N = \frac{D}{144\delta} [8(c_A - c_B) + 3\delta]^2.$$

When marginal costs are equal, then  $\Pi_A^N = \Pi_B^N = \frac{1}{16}D\delta$ .

### 5.3.3 Comparison of the Various Equilibrium Patterns in the Two-Outlet Case

#### Equilibrium Price Comparison

Table 5.1 (see page 147) summarises the results obtained in Section 5.3.1 and Section 5.3.2. For the sake of comparison, all values are expressed with a common denominator. It appears that the noncooperative Nash prices are larger in a neighbouring outlet equilibrium. In other words, the interlaced outlet location yields more competitive Nash prices. This is a very intuitive result. Price competition is reduced as the number of Firm *A*'s outlets which directly compete with Firm *B*'s outlets decreases. Put differently, price competition is relaxed when firms own adjacent outlets.

Table 5.1: Equilibrium Price Comparison

<i>Interlaced Equilibrium</i>	<i>Neighbouring Equilibrium</i>
$p_A^{1*} = p_A^{2*} = \frac{189}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$	$p_A^{1*} = p_A^{2*} = \frac{378}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$
$p_B^{1*} = p_B^{2*} = \frac{189}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$	$p_B^{1*} = p_B^{2*} = \frac{378}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$

### Consumer Loss and Welfare

In this section I compare the two location patterns in terms of market performance ( $\Pi_{A,B}^E$ ,  $E = I, N$ ), consumer loss ( $CL^E$ ) (f.o.b. mill price plus transport costs given the inelastic demand) and welfare loss ( $WL^E$ ) (transport costs, i.e., disutility). For the sake of simplicity, let us assume that marginal costs are identical, i.e.,  $c_A = c_B = c$ . Without loss of generality, let the marginal costs be zero.

#### Interlaced Outlet Location

Since all consumers pay the same f.o.b. mill price,  $\frac{\delta}{16}$ , total revenue is  $\frac{D\delta}{16}$ . Given the locations of the marginal consumers  $z_l^*$  ( $l = 1, \dots, 4$ ) (see Section 5.3.1), transportation costs,  $T^I$ , are given by

$$T^I = D \left( 8 \int_{s=0}^{s=1/8} [\delta s^2] ds \right). \quad (5.32)$$

Explicit evaluation of (5.32) yields  $\frac{D\delta}{192}$ , so that

$$CL^I = -\left( \frac{D\delta}{16} + \frac{D\delta}{192} \right) = -\left( \frac{13D\delta}{192} \right). \quad (5.33)$$

#### Neighbouring Outlet Location

Now all consumers pay the same f.o.b. mill price,  $\frac{\delta}{8}$ , and total revenue is  $\frac{D\delta}{8}$ . Given the locations of the marginal consumers  $z_l^*$  ( $l = 1, \dots, 4$ ) (see Section 5.3.2), transportation costs,  $T^N$ , are

$$T^N = D \left( 8 \int_{s=0}^{s=1/8} [\delta s^2] ds \right). \quad (5.34)$$

Notice that (5.34) is equal to (5.32), so that the transportation costs paid by consumers amount to  $\frac{D\delta}{192}$ . Finally,

$$CL^N = -\left( \frac{D\delta}{8} + \frac{D\delta}{192} \right) = -\left( \frac{25D\delta}{192} \right). \quad (5.35)$$

Table 5.2 summarises these results. For the sake of comparison, all values are expressed with a common denominator. Notice that when marginal costs are identical, each firm covers 50% of the market and industry profits are twice the profit of a single firm. The results of Table 5.1 and Table 5.2 provide a proof of Proposition 1.

Table 5.2: Comparison of the Equilibrium Values

	<i>Interlaced Equilibrium</i>	<i>Neighbouring Equilibrium</i>
Industry Profit	$\frac{47628}{762048} D\delta$	$\frac{95256}{762048} D\delta$
Consumer Surplus (CL)	$-\frac{51597}{762048} D\delta$	$-\frac{99225}{762048} D\delta$
Welfare Loss (WL)	$-\frac{3969}{762048} D\delta$	$-\frac{3969}{762048} D\delta$

The aim of the next section is to provide a similar analysis for the three-outlet case.

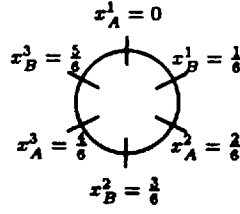
## 5.4 Spatial Multiproduct Duopoly Pricing: The Three-Outlet Case

**Proposition 2** *Consider two duopolists, each owning three outlets. Locations are exogenously given. Three different symmetric location patterns are analysed: (1) An interlaced outlet equilibrium, (2) a neighbouring outlet equilibrium, and (3) a mixed outlet equilibrium. Given the location pattern and the assumptions of Section 5.2, the noncooperative Nash prices are larger in a neighbouring outlet equilibrium, ceteris paribus. The interlaced outlet equilibrium yields the more competitive Nash prices. Nash prices with the mixed outlet equilibrium are lower than with a neighbouring location but higher than with an interlaced location. Profits follow the same pattern, i.e., the highest profits are obtained under the neighbouring location whereas the lowest profits are obtained under the interlaced location. Finally, social welfare is higher under the interlaced location. Neighbouring location is the less socially desirable pattern.*

### 5.4.1 The Interlaced Outlet Equilibrium

Let outlet locations and mill prices be given by  $x_k^i$  and  $p_k^i$ , respectively with  $i = 1, 2, 3$  and  $k = A, B$ . Figure 5.4 (see page 149) depicts the candidate (symmetric) equilibria for the interlaced outlet location.

Figure 5.4: Interlaced Locations in the Three Outlet Case



Using (5.2), the locations of the marginal consumer,  $z_l(\cdot)$  ( $l = 1, \dots, 6$ ), are

$$z_1(\cdot) = \frac{1}{12} + \frac{3}{\delta}(p_B^1 - p_A^1), \quad (5.36)$$

$$z_2(\cdot) = \frac{3}{12} + \frac{3}{\delta}(p_A^2 - p_B^1), \quad (5.37)$$

$$z_3(\cdot) = \frac{5}{12} + \frac{3}{\delta}(p_B^2 - p_A^2), \quad (5.38)$$

$$z_4(\cdot) = \frac{7}{12} + \frac{3}{\delta}(p_A^3 - p_B^2), \quad (5.39)$$

$$z_5(\cdot) = \frac{9}{12} + \frac{3}{\delta}(p_B^3 - p_A^3), \quad (5.40)$$

$$z_6(\cdot) = \frac{11}{12} + \frac{3}{\delta}(p_A^1 - p_B^3). \quad (5.41)$$

Given (5.36)-(5.41) we derive the market shares  $S_k^i(\cdot)$  for each outlet. Market shares,  $S_k^i(\cdot)$ , are

$$S_A^1(\cdot) = z_1 + 1 - z_6 = \frac{1}{6} - \frac{6}{\delta}p_A^1 + \frac{3}{\delta}(p_B^1 + p_B^3), \quad (5.42)$$

$$S_B^1(\cdot) = z_2 - z_1 = \frac{1}{6} - \frac{6}{\delta}p_B^1 + \frac{3}{\delta}(p_A^1 + p_A^2), \quad (5.43)$$

$$S_A^2(\cdot) = z_3 - z_2 = \frac{1}{6} - \frac{6}{\delta}p_A^2 + \frac{3}{\delta}(p_B^1 + p_B^2), \quad (5.44)$$

$$S_B^2(\cdot) = z_4 - z_3 = \frac{1}{6} - \frac{6}{\delta}p_B^2 + \frac{3}{\delta}(p_A^2 + p_A^3), \quad (5.45)$$

$$S_A^3(\cdot) = z_5 - z_4 = \frac{1}{6} - \frac{6}{\delta}p_A^3 + \frac{3}{\delta}(p_B^2 + p_B^3), \quad (5.46)$$

$$S_B^3(\cdot) = z_6 - z_5 = \frac{1}{6} - \frac{6}{\delta}p_B^3 + \frac{3}{\delta}(p_A^1 + p_A^3). \quad (5.47)$$

Firm A's and Firm B's profits can be expressed as

$$\Pi_A^I(\cdot) = D\left(\sum_{i=1}^3 (p_A^i - c_A) S_A^i(\cdot)\right), \quad (5.48)$$

and

$$\Pi_B^I(\cdot) = D\left(\sum_{i=1}^3 (p_B^i - c_B) S_B^i(\cdot)\right), \quad (5.49)$$

respectively, where the subscript 'I' stands for interlaced locations. The noncooperative Nash prices are solutions of the system of first order conditions

$$\frac{\partial \Pi_k^I(\cdot)}{\partial p_k^i} = 0 \quad i = 1, 2, 3 \quad k = A, B. \quad (5.50)$$

and equal to

$$p_A^{1*} = p_A^{2*} = p_A^{3*} = \frac{1}{36}\delta + \frac{1}{3}(c_B + 2c_A), \quad (5.51)$$

$$p_B^{1*} = p_B^{2*} = p_B^{3*} = \frac{1}{36}\delta + \frac{1}{3}(c_A + 2c_B). \quad (5.52)$$

Equilibrium prices are again an increasing function of both the marginal costs and the transportation rate  $\delta$ . Notice that when marginal costs are identical,  $c_A = c_B = c$ , the price-cost margin is  $\delta/36$ . This is the equilibrium price that would result if each outlet were operated by a single firm. Plugging the Nash prices (5.51)-(5.52) into the market boundaries (5.36)-(5.41), we can evaluate the market shares (5.42)-(5.47):

$$\begin{aligned} z_1^* &= \frac{1}{12} + \frac{c_B - c_A}{\delta}, z_2^* = \frac{3}{12} + \frac{c_A - c_B}{\delta}, z_3^* = \frac{5}{12} + \frac{c_B - c_A}{\delta}, \\ z_4^* &= \frac{7}{12} + \frac{c_A - c_B}{\delta}, z_5^* = \frac{9}{12} + \frac{c_B - c_A}{\delta}, z_6^* = \frac{11}{12} + \frac{c_A - c_B}{\delta}, \end{aligned}$$

and

$$\begin{aligned} S_A^{i*} &= \frac{1}{6} + \frac{2(c_B - c_A)}{\delta}, \quad i = 1, 2, 3 \\ S_B^{i*} &= \frac{1}{6} + \frac{2(c_A - c_B)}{\delta}, \quad i = 1, 2, 3. \end{aligned}$$

Finally, the profit functions (5.48)-(5.49) are equal to

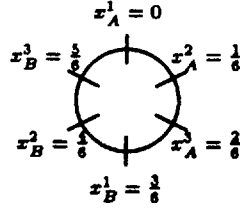
$$\begin{aligned} \Pi_A^I &= \frac{D}{72\delta} [12(c_B - c_A) + \delta]^2, \\ \Pi_B^I &= \frac{D}{72\delta} [12(c_B - c_A) - \delta]^2. \end{aligned}$$

When marginal costs are equal, we have  $\Pi_A^I = \Pi_B^I = \frac{1}{72}D\delta$ .

### 5.4.2 The Neighbouring Outlet Equilibrium

Figure 5.5 (see page 151) depicts the candidate (symmetric) equilibria for the neighbouring outlet location. From Figure 5.5 it appears that the outlet located at  $x_A^2(x_B^2)$  is fully isolated from Firm  $B$ 's (Firm  $A$ 's) outlets.





Using (5.2), the locations of the marginal consumer,  $z_l(\cdot)$  ( $l = 1, \dots, 6$ ), are

$$z_1(\cdot) = \frac{1}{12} + \frac{3}{\delta}(p_A^2 - p_A^1), \quad (5.53)$$

$$z_2(\cdot) = \frac{3}{12} + \frac{3}{\delta}(p_A^3 - p_A^2), \quad (5.54)$$

$$z_3(\cdot) = \frac{5}{12} + \frac{3}{\delta}(p_B^1 - p_A^3), \quad (5.55)$$

$$z_4(\cdot) = \frac{7}{12} + \frac{3}{\delta}(p_B^2 - p_B^1), \quad (5.56)$$

$$z_5(\cdot) = \frac{9}{12} + \frac{3}{\delta}(p_B^3 - p_B^2), \quad (5.57)$$

$$z_6(\cdot) = \frac{11}{12} + \frac{3}{\delta}(p_A^1 - p_B^3). \quad (5.58)$$

Given (5.53)-(5.58), the market shares  $S_k^i(\cdot)$  for each outlet are

$$S_A^1(\cdot) = z_1 + 1 - z_6 = \frac{1}{6} - \frac{6}{\delta}p_A^1 + \frac{3}{\delta}(p_A^2 + p_B^3), \quad (5.59)$$

$$S_A^2(\cdot) = z_2 - z_1 = \frac{1}{6} - \frac{6}{\delta}p_A^2 + \frac{3}{\delta}(p_A^1 + p_A^3), \quad (5.60)$$

$$S_A^3(\cdot) = z_3 - z_2 = \frac{1}{6} - \frac{6}{\delta}p_A^3 + \frac{3}{\delta}(p_B^1 + p_A^2), \quad (5.61)$$

$$S_B^1(\cdot) = z_4 - z_3 = \frac{1}{6} - \frac{6}{\delta}p_B^1 + \frac{3}{\delta}(p_B^2 + p_A^3), \quad (5.62)$$

$$S_B^2(\cdot) = z_5 - z_4 = \frac{1}{6} - \frac{6}{\delta}p_B^2 + \frac{3}{\delta}(p_B^1 + p_B^3), \quad (5.63)$$

$$S_B^3(\cdot) = z_6 - z_5 = \frac{1}{6} - \frac{6}{\delta}p_B^3 + \frac{3}{\delta}(p_A^1 + p_B^2). \quad (5.64)$$

As before, Firm A and Firm B's problem reduces to maximising

$$\Pi_A^N(\cdot) = D\left(\sum_{i=1}^{i=3}(p_A^i - c_A)S_A^i(\cdot)\right), \quad (5.65)$$

and

$$\Pi_B^N(\cdot) = D\left(\sum_{i=1}^{i=3}(p_B^i - c_B)S_B^i(\cdot)\right), \quad (5.66)$$

respectively, where the subscript 'N' stands for neighbouring locations. The non-cooperative Nash prices are solutions of the system

$$\frac{\partial \Pi_k^N(\cdot)}{\partial p_k^i} = 0 \quad i = 1, 2, 3 \quad k = A, B. \quad (5.67)$$

and equal to

$$p_A^{1*} = p_A^{3*} = \frac{6}{72}\delta + \frac{1}{3}(c_B + 2c_A), \quad p_A^{2*} = \frac{7}{72}\delta + \frac{1}{3}(c_B + 2c_A), \quad (5.68)$$

and

$$p_B^{1*} = p_B^{3*} = \frac{6}{72}\delta + \frac{1}{3}(c_A + 2c_B), \quad p_B^{2*} = \frac{7}{72}\delta + \frac{1}{3}(c_A + 2c_B). \quad (5.69)$$

Notice that  $p_A^{2*} > p_A^{1*} = p_A^{3*}$ , and  $p_B^{2*} > p_B^{1*} = p_B^{3*}$ . Firm  $A$ 's (Firm  $B$ 's) market power is higher at location  $x_A^2(x_B^2)$  since, at that location, there is a reduction in the drive to compete for the marginal consumers located at  $z_1$  and  $z_2$  ( $z_4$  and  $z_5$ ). Plugging the Nash prices (5.68)-(5.69) into the market boundaries (5.53)-(5.58), we obtain

$$z_1^* = \frac{3}{24}, z_2^* = \frac{5}{24}, z_3^* = \frac{10\delta + 24(c_B - c_A)}{24\delta}, \\ z_4^* = \frac{15}{24}, z_5^* = \frac{17}{24}, z_6^* = \frac{22\delta - 24(c_A - c_B)}{24\delta},$$

and

$$S_A^{1*} = S_A^{3*} = \frac{5\delta + 24(c_B - c_A)}{24\delta}, S_A^{2*} = \frac{1}{12}, \\ S_B^{1*} = S_B^{3*} = \frac{5\delta + 24(c_A - c_B)}{24\delta}, S_B^{2*} = \frac{1}{12}.$$

The profit functions are

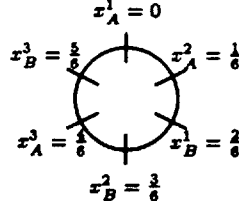
$$\Pi_A^N = \frac{D}{864\delta} [288(c_B - c_A)(2c_B - 2c_A + \delta) + 37\delta^2], \\ \Pi_B^N = \frac{D}{864\delta} [288(c_B - c_A)(2c_B - 2c_A - \delta) + 37\delta^2].$$

With equal marginal costs,  $\Pi_A^N = \Pi_B^N = \frac{37}{864}D\delta$ .

### 5.4.3 The Mixed Outlet Equilibrium

In this section, I investigate how the equilibrium prices are affected under the mixed outlet equilibrium. Let us focus on the mixed outlet equilibrium represented in Figure 5.6 (see page 153). Each firm now owns two adjacent outlets and one interlaced outlet. The mixed outlet equilibrium is likely to be a combination of the previous two cases.

Figure 5.6: Mixed Locations with three Outlets



The locations of the marginal consumer,  $z_l(\cdot)$  ( $l = 1, \dots, 6$ ), are

$$z_1(\cdot) = \frac{1}{12} + \frac{3}{\delta}(p_A^2 - p_A^1), \quad (5.70)$$

$$z_2(\cdot) = \frac{3}{12} + \frac{3}{\delta}(p_B^1 - p_A^2), \quad (5.71)$$

$$z_3(\cdot) = \frac{5}{12} + \frac{3}{\delta}(p_B^2 - p_B^1), \quad (5.72)$$

$$z_4(\cdot) = \frac{7}{12} + \frac{3}{\delta}(p_A^3 - p_B^2), \quad (5.73)$$

$$z_5(\cdot) = \frac{9}{12} + \frac{3}{\delta}(p_B^3 - p_A^3), \quad (5.74)$$

$$z_6(\cdot) = \frac{11}{12} + \frac{3}{\delta}(p_A^1 - p_B^3). \quad (5.75)$$

while the market shares,  $S_k^i(\cdot)$ , are

$$S_A^1(\cdot) = z_1 + 1 - z_6 = \frac{1}{6} - \frac{6}{\delta}p_A^1 + \frac{3}{\delta}(p_A^2 + p_B^3), \quad (5.76)$$

$$S_A^2(\cdot) = z_2 - z_1 = \frac{1}{6} - \frac{6}{\delta}p_A^2 + \frac{3}{\delta}(p_A^1 + p_B^1), \quad (5.77)$$

$$S_A^3(\cdot) = z_5 - z_4 = \frac{1}{6} - \frac{6}{\delta}p_A^3 + \frac{3}{\delta}(p_B^2 + p_B^3), \quad (5.78)$$

$$S_B^1(\cdot) = z_3 - z_2 = \frac{1}{6} - \frac{6}{\delta}p_B^1 + \frac{3}{\delta}(p_A^2 + p_B^2), \quad (5.79)$$

$$S_B^2(\cdot) = z_4 - z_3 = \frac{1}{6} - \frac{6}{\delta}p_B^2 + \frac{3}{\delta}(p_B^1 + p_A^3), \quad (5.80)$$

$$S_B^3(\cdot) = z_6 - z_5 = \frac{1}{6} - \frac{6}{\delta}p_B^3 + \frac{3}{\delta}(p_A^1 + p_A^3). \quad (5.81)$$

Firm A and Firm B's problem is to maximise

$$\Pi_A^M(\cdot) = D\left(\sum_{i=1}^3 (p_A^i - c_A) S_A^i(\cdot)\right), \quad (5.82)$$

and

$$\Pi_B^M(\cdot) = D\left(\sum_{i=1}^3 (p_B^i - c_B) S_B^i(\cdot)\right), \quad (5.83)$$

respectively, where the subscript 'M' stands for mixed locations. The noncooperative Nash equilibrium prices are solutions of the system of 6 first order conditions

$$\frac{\partial \Pi_k^M(\cdot)}{\partial p_k^i} = 0 \quad i = 1, 2, 3 \quad k = A, B. \quad (5.84)$$

and equal to

$$p_A^{1*} = \frac{18}{378}\delta + \frac{1}{3}(c_B + 2c_A), \quad (5.85)$$

$$p_A^{2*} = \frac{19}{378}\delta + \frac{1}{3}(c_B + 2c_A), \quad (5.86)$$

$$p_A^{3*} = \frac{13}{378}\delta + \frac{1}{3}(c_B + 2c_A), \quad (5.87)$$

and

$$p_B^{1*} = \frac{19}{378}\delta + \frac{1}{3}(c_A + 2c_B), \quad (5.88)$$

$$p_B^{2*} = \frac{18}{378}\delta + \frac{1}{3}(c_A + 2c_B), \quad (5.89)$$

$$p_B^{3*} = \frac{13}{378}\delta + \frac{1}{3}(c_A + 2c_B). \quad (5.90)$$

In contrast with the previous cases, the f.o.b. mill price is different at each location  $x_{A,B}^i$  ( $i = 1, 2, 3$ ). Indeed,  $p_A^{2*} > p_A^{1*} > p_A^{3*}$ , and  $p_B^{1*} > p_B^{2*} > p_B^{3*}$ . It is interesting to observe that locations  $x_A^3$  and  $x_B^3$  face a lower mill price. At these locations Firm B's (Firm A) outlets surround the outlet located at  $x_A^3$  ( $x_B^3$ ). As a result, the rivalry to compete for the marginal consumers located at  $z_4, z_5$  and  $z_6$  is more important, ceteris paribus. Plugging the Nash prices (5.85)-(5.90) into the market boundaries (5.70)-(5.75), we obtain

$$z_1^* = \frac{23}{252}, z_2^* = \frac{63\delta + 252(c_B - c_A)}{252\delta}, z_3^* = \frac{103}{252}, z_4^* = \frac{137\delta + 252(c_A - c_B)}{252\delta},$$

$$z_5^* = \frac{189\delta + 252(c_B - c_A)}{252\delta}, z_6^* = \frac{241\delta - 252(c_A - c_B)}{252\delta},$$

and

$$S_A^{1*} = \frac{34\delta + 252(c_B - c_A)}{252\delta}, S_A^{2*} = \frac{40\delta + 252(c_B - c_A)}{252\delta}, S_A^{3*} = \frac{52\delta + 252(2c_B - 2c_A)}{252\delta},$$

$$S_B^{1*} = \frac{40\delta + 252(c_A - c_B)}{252\delta}, S_B^{2*} = \frac{34\delta + 252(c_A - c_B)}{252\delta}, S_B^{3*} = \frac{52\delta + 252(2c_A - 2c_B)}{252\delta}.$$

Finally,

$$\Pi_A^M = \frac{D}{11907\delta} [3969(c_A - c_B)(4c_A - 4c_B - \delta) + 256\delta^2],$$

$$\Pi_B^M = \frac{D}{11907\delta} [3969(c_A - c_B)(4c_A - 4c_B + \delta) + 256\delta^2].$$

It is straightforward to note that when marginal costs are equal,  $\Pi_A^M = \Pi_B^M = \frac{256}{11907}D\delta$ .

#### 5.4.4 Comparison of the Various Equilibrium Patterns in the Three-Outlet Case

##### Equilibrium Price Comparison

Table 5.3 summarises the results obtained in Section 5.4.1, Section 5.4.2 and Section 5.4.3.

Table 5.3: Equilibrium Price Comparison

<i>Interlaced Equilibrium</i>	<i>Mixed Equilibrium</i>	<i>Neighbouring Equilibrium</i>
$p_A^{1*} = \frac{84}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$	$p_A^{1*} = \frac{144}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$	$p_A^{1*} = \frac{252}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$
$p_A^{2*} = \frac{84}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$	$p_A^{2*} = \frac{152}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$	$p_A^{2*} = \frac{294}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$
$p_A^{3*} = \frac{84}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$	$p_A^{3*} = \frac{104}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$	$p_A^{3*} = \frac{252}{3024}\delta + \frac{1}{3}(c_B + 2c_A)$
$p_B^{1*} = \frac{84}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$	$p_B^{1*} = \frac{152}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$	$p_B^{1*} = \frac{252}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$
$p_B^{2*} = \frac{84}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$	$p_B^{2*} = \frac{144}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$	$p_B^{2*} = \frac{294}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$
$p_B^{3*} = \frac{84}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$	$p_B^{3*} = \frac{104}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$	$p_B^{3*} = \frac{252}{3024}\delta + \frac{1}{3}(c_A + 2c_B)$

The noncooperative Nash prices are larger in a neighbouring outlet equilibrium. The interlaced outlet equilibrium yields the more competitive Nash prices. Nash prices with the mixed outlet equilibrium are lower than with a neighbouring location but higher than with an interlaced location. Consequently, prices are increasing as the number of Firm A's (Firm B's) neighbouring outlets increases. This is an appealing result. Price competition is reduced as the number of Firm A's outlets which directly compete with Firm B's outlets decreases. Put differently, as the number of neighbouring outlets increases, each firm coordinates its pricing policy in order to avoid 'cannibalization' between its own outlets. As a result, market power increases as the number of neighbouring outlets increases.

##### Consumer Loss and Welfare

In this section, I compare the three location patterns in terms of market performance ( $\Pi_{A,B}^E$ ,  $E = I, N, M$ ), consumer loss ( $CL^E$ ) (f.o.b. mill price plus transport costs given the inelastic demand) and welfare loss ( $WL^E$ ) (transport costs). Again, assume that  $c_A = c_B = c = 0$ .

##### Interlaced Outlet Location

Since all consumers pay the same f.o.b. mill price,  $\frac{\delta}{36}$ , total revenue (price paid by all consumers) is  $\frac{D\delta}{36}$ . Given the locations of the marginal consumers  $z_i^*$

( $l = 1, \dots, 6$ ) (see Section 5.4.1), transportation costs,  $T^I$ , are given by

$$T^I = D \left( 12 \int_{s=0}^{s=1/12} [\delta s^2] ds \right). \quad (5.91)$$

Evaluating expression (5.91) yields  $\frac{D\delta}{432}$ . Consequently,

$$CL^I = -\left(\frac{D\delta}{36} + \frac{D\delta}{432}\right) = -\left(\frac{13D\delta}{432}\right). \quad (5.92)$$

### Neighbouring Outlet Location

In this case things are a bit more complicated since not all consumers pay the same f.o.b. mill price (see Section 5.4.2). Indeed, in equilibrium,  $\frac{20}{24} \cong 83.3\%$  of consumers pay a f.o.b. mill price equal to  $6\delta/72$ , while  $\frac{4}{24} \cong 16.6\%$  of consumers pay a price equal to  $7\delta/72$ . The latter price is paid by the consumers located at proximity of  $x_A^2$  and  $x_B^2$ . It is straightforward to show that total revenue amounts to  $\frac{37D\delta}{432}$ . Given the locations of the marginal consumers  $z_l^*$  ( $l = 1, \dots, 6$ ), transportation costs,  $T^N$ , are given by

$$T^N = D \left( 4 \int_{s=0}^{s=1/24} [\delta s^2] ds + 4 \int_{s=0}^{s=2/24} [\delta s^2] ds + 4 \int_{s=0}^{s=3/24} [\delta s^2] ds \right). \quad (5.93)$$

Explicit evaluation of (5.93) yields  $\frac{D\delta}{288}$ , so that

$$CL^N = -\left(\frac{37D\delta}{432} + \frac{D\delta}{288}\right) = -\left(\frac{77D\delta}{864}\right). \quad (5.94)$$

### Mixed Outlet Location

In equilibrium, consumers pay three different f.o.b. mill prices (see Section 5.4.3). It can be shown that,  $\frac{68}{252} \cong 27.0\%$  of consumers pay a price equal to  $18\delta/378$ ,  $\frac{80}{252} \cong 31.7\%$  pay a price equal to  $19\delta/378$ , and finally  $\frac{104}{252} \cong 41.3\%$  of consumers pay a price equal to  $13\delta/378$ . The latter, more competitive price is paid by the consumers located at proximity of  $x_A^3$  and  $x_B^3$ . Hence, total revenue amounts to  $\frac{512D\delta}{11907}$ . Given the locations of the marginal consumers  $z_l^*$  ( $l = 1, \dots, 6$ ), transportation costs,  $T^M$ , are

$$T^M = D \left( 2 \int_{s=0}^{s=\frac{11}{252}} [\delta s^2] ds + 2 \int_{s=0}^{s=\frac{19}{252}} [\delta s^2] ds + 4 \int_{s=0}^{s=\frac{21}{252}} [\delta s^2] ds + 2 \int_{s=0}^{s=\frac{31}{252}} [\delta s^2] ds \right). \quad (5.95)$$

Explicit evaluation of (5.95) yields  $\frac{545D\delta}{190512}$ . It follows that

$$CL^M = -\left(\frac{512D\delta}{11907} + \frac{545D\delta}{190512}\right) = -\left(\frac{8737D\delta}{190512}\right). \quad (5.96)$$

Table 5.4 summarises these results. Notice that when marginal costs are identical, each firm covers 50% of the market and industry profits are twice the profit of a single firm.

Table 5.4: Comparison of the Equilibrium Values

	<i>Interlaced Equilibrium</i>	<i>Mixed Equilibrium</i>	<i>Neighbouring Equilibrium</i>
Industry Profit	$\frac{21168}{762048} D\delta$	$\frac{32768}{762048} D\delta$	$\frac{65268}{762048} D\delta$
Consumer Loss (CL)	$-\frac{22932}{762048} D\delta$	$-\frac{34948}{762048} D\delta$	$-\frac{67914}{762048} D\delta$
Welfare Loss (WL)	$-\frac{1764}{762048} D\delta$	$-\frac{2180}{762048} D\delta$	$-\frac{2646}{762048} D\delta$

Neighbouring locations give rise to significantly higher profits. Social welfare (or average transport costs) is higher under the interlaced location. The results of Table 5.4 suggest that neighbouring location is the less socially desirable pattern. Notice that all results were obtained with outlets assumed to be equispaced. Therefore, in equilibrium, different transportation costs (or welfare) arise because different mill prices are charged by duopolists. The results of Table 5.3 and Table 5.4 provide a proof of Proposition 2.

In summary, the results of Proposition 1 and Proposition 2 show that both prices and market performance are higher under a neighbouring location pattern. It is important to note that the interlaced location and neighbouring location constitute the two benchmark cases. When the number of outlets is larger than two, the mixed location equilibrium yields intermediate results<sup>5</sup>. I would like to stress that the results of Proposition 1 and of Proposition 2 are likely to hold under alternative assumptions, in particular, with an elastic (downward sloping) demand and/or a two stage location-then-price equilibrium with more than two firms. However, it still remains to study the sensitivity of this result to a non uniform demand distribution.

Finally, a last result is derived from the comparison between the two-outlet case (Section 5.3) and the three-outlet case (Section 5.4).

**Proposition 3** *Given the results of Proposition 1 (Section 5.3) and Proposition 2 (Section 5.4), we have that both noncooperative Nash prices and profits are higher in the two-outlet case, ceteris paribus. Social welfare, however, is higher in the three-outlet case.*

<sup>5</sup>As the number of outlet increases, a multiplicity of different mixed equilibria emerges.

The proof of Proposition 3 directly follows from the comparison of Tables (5.1)-(5.2) and Tables (5.3)-(5.4). Given the inelastic demand assumption, it is not surprising that prices and profits are higher in the two-outlet case. This arises because two contrasting effects are at work when a third outlet is introduced. The introduction of the third outlet has a positive market share effect (through a better market segmentation) but a negative price effect due to the increase in price competition. Here, we show that the negative price effect dominates the positive market share effect. This latter result is similar to Martinez-Giralt & Neven [1988]. However, with quadratic utility loss, social welfare is higher in the three-outlet case. This occurs because the introduction of a third outlet allows consumers to incur lower average transportation costs.

## 5.5 A Model for Comparing Prices Across Airline Markets with Different Location Patterns

### 5.5.1 Introduction

My principal objective in the remaining part of this chapter is to estimate a model of (multiproduct) duopoly pricing when the location patterns (in the time domain) differ across markets. I apply this model to data for intra-European duopoly airline markets, strictly defined, in that two carriers (principally flag-carriers) offer all of the (nonstop) direct services on a given city-pair. The empirical study covers the October 1993 period (the data are described more fully in Section 5.5.3).

In this section, I model intra-European airline markets as an one-dimensional (horizontally) differentiated industry. Rather than Hotelling's [1929] celebrated 'distance' assumption, we now have 'time'. I follow Panzar [1979] in modelling airline competition within the one-dimensional 'address' model framework. Therefore, it is assumed that airlines produce a homogeneous product (in the consumers' eyes) except for the time dimension<sup>6</sup>. This seems reasonable if, as is postulated in the empirical model, duopolists are symmetric in the level of service frequency. Actually, many intra-European markets are characterised by a symmetric duopoly structure with both airlines providing an identical number of daily flights and capturing similar market shares. This unique market structure leads to a number of reasonable simplifications which in turn allow me to test the implications of location patterns in the time domain (one important aspect of the organisational structure of the market) on pricing behaviour (market conduct).

Indeed, I consider the European airline industry as a unique and natural framework for testing the predictions of spatial multiproduct duopoly pricing. The

---

<sup>6</sup>Notice that contrary to most quality variables and/or other characteristics dimensions, airline scheduling time is (unambiguously) observable.



model suggests than duopolist firms with neighbouring outlet locations choose higher (noncooperative) Nash prices than those resulting under interlaced locations. In other words, on a given route (city-pair), duopolist airlines operating aircraft with interlaced departure times would charge lower equilibrium prices, *ceteris paribus*. The results of this chapter suggest that policy-makers and airport authorities should cautiously consider the implications of departure times for market power and social welfare when awarding slots to competing duopolies. In effect, the present research suggests that there is a potential for the neighbouring pattern to be a source of market power.

This work extends the already large body of literature that studies the determination of fares in airline city-pair markets<sup>7</sup>. Typically, the literature explores the connection between fares and market-specific variables, which include measures of demand (city populations, incomes, etc.), costs (flight distance, load factor, etc.) and market structure (number of competitors, market share, airport presence, etc.). Recently, the inclusion of network characteristics has given new insights. On the one hand, network characteristics play a significant role in consumer choice among competing airlines (e.g., Berry<sup>8</sup> [1990]). On the other hand, network characteristics can play an important role on costs and therefore on fares. For example, Brueckner, Dyer & Spiller [1992] and Brueckner & Spiller [1994] emphasised that hub-and-spoke networks generate cost reductions through economies of traffic density. In comparison to the existing literature, the present work is differentiated in the following two major aspects. First, it focuses on intra-European airline markets<sup>9</sup>. Second, it focuses on one particularly important aspect of airline competition: The implications of the location pattern of daily flights in the time domain on pricing behaviour.

Airlines can be thought of as complex multiproduct firms. First, because each route can be considered a different product and second, because within each route an airline operates several air services. For the purpose of this analysis, a multiproduct airline is an airline operating several daily aircraft on a given intra-European route. Assuming that the intra-European air services market can be characterised by a model of spatial duopolistic competition, it is possible to represent the airline decision process as the following (schematic) two stage game:

---

<sup>7</sup>Almost all of the existing literature focuses on U.S. airline markets. The most recent studies include Bailey, Graham & Kaplan [1985], Berry [1990], Borenstein [1989,1990], Brueckner, Dyer & Spiller [1992], Brueckner & Spiller [1994], Call & Keeler [1985], Evans & Kessides [1993a,1993b], Graham, Kaplan & Sibley [1983], Hurdle et al.[1989], Morrison & Winston [1989,1990] and Peteraf & Reed [1994] among others.

<sup>8</sup>Berry [1990] estimates a discrete choice model of product differentiation for the U.S. airline industry. According to Berry [1990], air transportation services are differentiated because, on a given city-pair market, airlines' network characteristics (e.g., airport presence, network size) vary.

<sup>9</sup>Recently, Marin [1995] models European airline competition as a vertically and horizontally differentiated industry. However, contrary to the present work, Marin [1995] analyses the impact of liberal bilateral agreements on some European airline markets.

1. At the very beginning, the airline decides whether to enter the intra-European market, and if so, it makes a choice about its technology. Then, the airline has to decide how many daily aircraft to operate on the market and at which departure time. The former is the product range decision and the latter the product selection (location) decision.
2. In the second stage of the game, the airline sets noncooperative prices given the decisions of the previous stage.

The first stage may be considered as long term decisions, whereas the last more flexible stage may be viewed as a short term decision (see Bresnahan [1989]). For the purpose of this analysis, I focus on the last stage of the decision process, when airlines take the departure times, the number of aircraft operated and the set of markets they operate in as given. One can argue that this assumption is rather restrictive on the grounds that airlines generally control both price and schedule simultaneously<sup>10</sup>. However, in the case of intra-European airline markets, carriers do not always control the schedule variable, because much of the infrastructure needed by airlines is publicly provided. Indeed, in most of the intra-European markets (city-pairs), the choice of the (offered) departure time greatly depends on local airport authorities which allocate available slots<sup>11</sup>. Typically, a slot of 10-15 minutes is allocated to the airline which must then make sure that its actual departure (and landing) time falls within this slot. At slot-constrained airports, a carrier is practically stuck within its allocated slot.

### 5.5.2 The Theoretical Structure

In this section I closely follow the work of Dresner & Tretheway [1992] who propose a method for comparing prices across international airline markets. These authors test the pricing behaviour in international airlines markets according to whether the route is operated under a liberal bilateral environment or under a traditional (bilateral) regulatory agreement. Although the assumptions underlying our model are completely different, it turns out that their methodology provides an interesting framework for modelling intra-European duopoly airline competition. For the purpose of this analysis, I focus on the two benchmark cases: The interlaced location and the neighbouring location.

In order to put more structure on the empirical model let us assume that the cost

---

<sup>10</sup>Theoretically it is costless to reschedule an airplane ('capital is mobile' according to the supporters of the [perfect] contestability theory (Baumol, Panzar & Willig [1982])). However, an airline typically operates several aircraft over its network and the relocation of a single flight generally induces the relocation of several other flights (given that aircraft are operated on a continuous basis). This suggests that the relocation of an aircraft can affect part of the network. Most of the time, this is not a costless operation.

<sup>11</sup>Several international European airports are severely slot-constrained due to airport and air space congestion.

function of firm  $k$  operating an aircraft  $i$  on the route  $r$ ,  $TC_{kr}^i(\cdot)$ , is given by

$$TC_{kr}^i(f_k^i, S_{kr}^i, \mathbf{x}_r) = f_k^i + VC_{kr}^i(S_{kr}^i, \mathbf{x}_r), \quad (5.97)$$

where  $f_k^i$  represents the fixed or overhead cost of operations allocated to each aircraft. Notice that  $f_k^i$  depends only on the carrier  $k$ , and not on the route itself. This is justified on the grounds that on the (medium-haul) intra-European routes an airline typically uses similar aircraft. Hence the fixed cost of operating an aircraft are carrier-specific rather than carrier-and-route-specific. The second element of (5.97),  $VC_{kr}^i$ , represents the variable cost of operating an aircraft on route  $r$ . This variable cost depends on a vector of route  $r$  characteristics,  $\mathbf{x}_r$  (such as the distance of the route and input prices the carrier faces), and on the level of output or traffic,  $S_{kr}^i$  (market shares), carried by the aircraft on that route. Equation (5.97) suggests that there are economies of scale from operating an aircraft on a particular route.

Using (5.97) to characterise the cost function, airline  $k$ 's profit function from operating airplanes on route  $r$ ,  $\Pi_{kr}(\cdot)$ , can be written as:

$$\Pi_{kr}(\cdot) = D_r \left[ \sum_i \left( p_{kr}^i S_{kr}^i(\cdot) - VC_{kr}^i(S_{kr}^i, \mathbf{x}_r) - f_k^i \right) \right], \quad (5.98)$$

where  $D_r$  stands for market  $r$ 's customers (uniform) density<sup>12</sup>, and  $p_{kr}^i$  is the price (strategy variable) chosen by airline  $k$  for its aircraft  $i$  in city-pair  $r$ . Implicit to (5.98) is the idea that costs can be separated at the aircraft and route level and that there are no economies of scope from operating several airplanes on a given route. It is also important to note that the demand for travelling in market  $r$ ,  $S_{kr}^i$ , does not depend upon prices in any of the other markets. Intuitively we can assume that customers who wish to travel from one city to another have no desire to travel anywhere else (i.e., zero cross-price elasticities between markets).

### The price equation under an interlaced location

Two airlines are supposed to play Bertrand-Nash price competition with given departure times. For the sake of simplicity, let us consider the pricing equation which arises when both carriers, Firm  $A$  and Firm  $B$ , operate two airplanes each (i.e.,  $i = 1, 2$ ) on a particular market. In this case, Firm  $A$ 's first order conditions are<sup>13</sup>

$$\frac{\partial \Pi_A}{\partial p_A^1} = D \left( S_A^1 + p_A^1 \frac{\partial S_A^1}{\partial p_A^1} - \frac{\partial VC_A^1}{\partial S_A^1} \frac{\partial S_A^1}{\partial p_A^1} + p_A^2 \frac{\partial S_A^2}{\partial p_A^1} - \frac{\partial VC_A^2}{\partial S_A^2} \frac{\partial S_A^2}{\partial p_A^1} \right) = 0, \quad (5.99)$$

<sup>12</sup>In Europe, due to airport noise restrictions, most flights are scheduled between 6.00 a.m to 10.00 p.m. For the purpose of this work, I assume that demand is uniformly distributed over the 'market length'. Note that all consumers are assumed to have an identical perfectly inelastic demand. The assumption of the basic spatial model is that different travellers have different most preferred time departures. For example, it may be important for a businessman to travel in the morning while for travellers visiting friends it may be more convenient to travel later.

<sup>13</sup>Omitting the subscript for the market.

$$\frac{\partial \Pi_A}{\partial p_A^2} = D \left( S_A^2 + p_A^2 \frac{\partial S_A^2}{\partial p_A^2} - \frac{\partial VC_A^2}{\partial S_A^2} \frac{\partial S_A^2}{\partial p_A^2} + p_A^1 \frac{\partial S_A^1}{\partial p_A^2} - \frac{\partial VC_A^1}{\partial S_A^1} \frac{\partial S_A^1}{\partial p_A^2} \right) = 0, \quad (5.100)$$

where the slope of the variable cost curve,  $\frac{\partial VC_A^i}{\partial S_A^i}$ , is defined as the marginal cost ( $mc_A^i$ ). Because the airline is assumed to operate similar aircraft throughout its (European) network it stands to reason that the marginal cost of operating airplanes is identical, so that  $mc_A^1 = mc_A^2 = mc_A$ . Moreover, in symmetric locations, the own price elasticities are equal such that  $\frac{\partial S_A^1}{\partial p_A^1} = \frac{\partial S_A^2}{\partial p_A^2}$ . Put differently, the slope of the aggregate demand is similar across 'outlets'.

With an interlaced location, carrier  $A$ 's airplanes are surrounded by carrier  $B$ 's airplanes. In other words, there is no scope for carrier  $A$  (and carrier  $B$ ) to "coordinate" its pricing policy between its own airplanes because airplanes of the same carrier are **strategically independent**. This is an important feature of the address model of (one-dimension) product differentiation which implicitly assumes localised competition. As a result, with an interlaced location, we have that  $\frac{\partial S_A^1}{\partial p_A^2} = \frac{\partial S_A^2}{\partial p_A^1} = 0$ . Accordingly, equations (5.99)-(5.100) can be rearranged with the dependent variables (i.e., prices) on the left hand side as follows

$$p_A^1 = mc_A(\cdot) - S_A^1 \frac{\partial p_A^1}{\partial S_A^1}, \quad (5.101)$$

$$p_A^2 = mc_A(\cdot) - S_A^2 \frac{\partial p_A^2}{\partial S_A^2}. \quad (5.102)$$

Equations (5.101)-(5.102) imply that mark-ups are inversely related to the elasticity of the aggregate demand faced by each airplane. Notice that in symmetric equilibrium, we have that carrier  $A$  would charge identical prices for its own airplanes.

### The price equation under a neighbouring location

Assume that, on a given market, carrier  $A$  operates two morning flights and carrier  $B$  operates two afternoon flights. In such a situation, each carrier has an incentive to relax price competition because it faces less competition from the rival. In effect, under this neighbouring location, there is scope for carrier  $A$  (and carrier  $B$ ) to "coordinate" its pricing policy since now its own airplanes are in direct competition. Airplanes of the same carrier are now **strategically dependent**. As a result, under a neighbouring location,  $\frac{\partial S_A^1}{\partial p_A^2} = \frac{\partial S_A^2}{\partial p_A^1} \neq 0$ . In other words, carrier  $A$  can internalise the effect of a change in the price  $p_A^1$  on the profit derived from operating the second aircraft. Accordingly, equations (5.99)-(5.100) can be rearranged to yield

$$p_A^1 = mc_A(\cdot) - S_A^1 \frac{\partial p_A^1}{\partial S_A^1} - \frac{\partial S_A^2}{\partial p_A^1} \frac{\partial p_A^1}{\partial S_A^1} [p_A^2 - mc_A], \quad (5.103)$$

$$p_A^2 = mc_A(\cdot) - S_A^2 \frac{\partial p_A^2}{\partial S_A^2} - \frac{\partial S_A^1}{\partial p_A^2} \frac{\partial p_A^2}{\partial S_A^1} [p_A^1 - mc_A]. \quad (5.104)$$

It can be observed, from examining equations (5.101)-(5.102) and equations (5.103)-(5.104), that the difference in prices charged by carrier  $A$  depends on the extra term

$$-\underbrace{\underbrace{\frac{\partial S_A^j}{\partial p_A^i}}_{>0} \underbrace{\frac{\partial p_A^i}{\partial S_A^i}}_{<0}}_{>0} [p_A^j - mc_A] \quad i, j = 1, 2 \quad i \neq j. \quad (5.105)$$

This extra term is positive for the following reasons. First,  $\partial S_A^j / \partial p_A^i$  is positive if substitutability between carrier  $A$ 's air services is assumed. Second,  $\partial p_A^i / \partial S_A^i$  is negative if I assume a downward sloping aggregate demand facing carrier  $A$ 's aircraft. Finally, the price cost margin is non negative given profit maximisation and assuming no subsidies (across airplanes and across markets) in the model. Accordingly, prices must be higher under a neighbouring location pattern.

The following single expression condenses carrier  $A$ 's pricing equations (5.101)-(5.102) and (5.103)-(5.104) under both location patterns, *ceteris paribus*:

$$p_A^i = mc_A(S_A^i, x) - \frac{\partial p_A^i}{\partial S_A^i} S_A^i + \gamma_1 (NBOR), \quad i, j = 1, 2 \quad i \neq j, \quad (5.106)$$

where,

$$\gamma_1 = -\frac{\partial S_A^j}{\partial p_A^i} \frac{\partial p_A^i}{\partial S_A^i} [p_A^j - mc_A] > 0, \quad (5.107)$$

and  $NBOR$  is a dummy variable defined as

$$NBOR = \begin{cases} 0 & \text{under an interlaced location pattern,} \\ 1 & \text{otherwise.} \end{cases} \quad (5.108)$$

Clearly, if the pricing scenario of the theoretical model is true, then prices should be lower under an interlaced location pattern. From the empirical point of view, equation (5.106) indicates that the sign of the coefficient of the traffic variable  $S_A^i$  may also be identified. Given the assumptions of the model,  $S_A^i$  has two distinct effects on  $p_A^i$ . First, when a carrier operates on the upward sloping part of its marginal cost curve, higher traffic levels lead to higher marginal costs. This effect may reflect the short run capacity constraints faced by the carrier when traffic increases. Hence, as an argument in the determination of the marginal cost  $mc_A(\cdot)$  one would expect output to have a positive effect on price. Second, since aggregate demand is assumed to be downward sloping, the sign of  $(-\partial p_A^i / \partial S_A^i)$  should be positive. As a consequence, since both the marginal cost effect and the demand effect should be positive, one would expect the coefficient of the traffic variable in the regression on price to be positive.

The idea now is to derive a route price equation using equation (5.106). Dresner & Tretheway [1992] propose an original way to do this. They argue that the use of *route-specific* variables may be reasonable when the analysis is focused on duopoly international airline markets, because prices and costs should

be fairly similar between duopolists at the route level. Since one would expect carriers' heterogeneity to be more important at the worldwide route level than at the intra-European route level, I follow Dresner & Tretheway's methodology in specifying a price equation at the route level rather than carrier-and-route level<sup>14</sup>. The steps leading to this specification are carefully justified throughout the remainder of this section. What is key in Dresner & Tretheway's analysis is the separation of the cost effects of output on price from the other route-specific cost effects. In other words, the variables representing those effects on the right hand side of (5.106) are entered separately (and additively). Carrier *A*'s equation (5.106) becomes

$$p_A = \gamma_1(NBOR) + \gamma_2 S_A + \gamma_3 x, \quad (5.109)$$

where  $\gamma_2$  is equal to  $(-\partial p_A / \partial S_A)$  plus the cost effects of traffic  $S_A$  on price.  $\gamma_3$  is the vector representing the effects of the route-specific cost variables (other than traffic) on price  $p_A$ . Notice that in (5.109), the subscript standing for aircraft *i* has been dropped since, at the equilibrium of the two airplane case, the carrier charges equal fares. Of course, there exists a similar expression for carrier *B*:

$$p_B = \theta_1(NBOR) + \theta_2 S_B + \theta_3 x, \quad (5.110)$$

with  $\theta_2$  representing  $(-\partial p_B / \partial S_B)$  plus the cost effects of traffic  $S_B$  on price and  $\theta_3$  capturing the effects of the route-specific cost variables (other than traffic) on price  $p_B$ . The summation of (5.109) and (5.110) yields

$$p_A + p_B = (\gamma_1 + \theta_1)(NBOR) + \gamma_2 S_A + \theta_2 S_B + (\gamma_3 + \theta_3)x. \quad (5.111)$$

Implicit to (5.111) is that the route-specific costs for carrier *A* are equal to the route-specific costs for carrier *B*. In other words, the  $x$  vectors are assumed to be the same at a route level. Finally, following Dresner & Tretheway, it is assumed that the fares charged on the route by the two carriers are the same (i.e.,  $p_A = p_B = p$ ) and that the effect of traffic on fare is the same for both duopolists, i.e.,  $\gamma_2 = \theta_2$ . Accordingly, equation (5.111) can be reformulated as

$$p = \alpha_1(NBOR) + \alpha_2 S + \alpha_3 x, \quad (5.112)$$

with  $\alpha_1 = (\gamma_1 + \theta_1)/2$ ,  $\alpha_2 = (\gamma_2 + \theta_2)/2$ ,  $\alpha_3 = (\gamma_3 + \theta_3)/2$ , and  $S$  is equal to the total passenger traffic on the route. The price equation (5.112) deserves several comments because the assumptions that allow us to derive it, in particular that duopolists charge equal fares and face equal costs at the route level, must be carefully justified.

First, note that (5.112) is a route-specific rather than carrier-and-route-specific equation. Therefore, using Evans & Kessides' terminology [1993a, 1993b], the present empirical study on airline pricing would be placed among the *first-generation*

---

<sup>14</sup>It is important to note that the route level specification requires less data. This is particularly useful given the lack of relevant data at the European carrier level.

studies which have been developed by many researchers such as Graham, Kaplan & Sibley [1983], Bailey, Graham & Kaplan [1985], Hurdle et al.[1989] and Peteraf & Reed [1994] among others. Recent empirical studies conducted on the domestic U.S. airline industry (Borenstein [1989], Berry [1990], Evans & Kessides [1993a,1993b], Abramowitz & Brown [1993]) indicate that the *first-generation* studies ignore important intra-route heterogeneity in firms characteristics. The latter authors argue that the most important firm characteristics that vary within the route are measures of airport dominance and network characteristics (e.g., size of the network). The *second-generation* studies undoubtedly constitute an improvement in explaining price differences among U.S. airlines serving domestic markets. However, since the present study focuses on duopolists carrier (primarily, flag-carriers) operating intra-European routes, it can be assumed that intra-firm differences in terms of market power (e.g., due to dominance at an airport) do not affect European airlines' pricing behaviour in the same way as they affect the U.S. markets. First, because market shares on a given market are very similar between duopolists. Second, dominance at an airport plays a minor role on intra-European markets: The advantages (disadvantages) Swissair (Lufthansa) may enjoy on the Geneva-Frankfurt route are likely to be reversed on the Frankfurt-Geneva route.

Second, I treat the output of duopolists as homogeneous (except in the time dimension of course). It can be argued that airlines compete both in terms of price and quality of service. The main aspect of the quality of service likely to influence the pricing behaviour of European airlines is the frequency of service<sup>15</sup>. In order to avoid any bias due to the frequency of service, I only consider duopoly routes with symmetric frequencies (as developed in the theoretical model).

Finally, implicit to the equation (5.112), is that the price equation at a route level is independent of carriers' network characteristics (e.g., size and configuration of the overall network). This can be justified on the grounds that the European network operated by each duopolist presents similar characteristics in terms of size and shape (hub-and-spoke) and that, in the data set, the number of routes operated by a particular airline corresponds to a small part of its overall network. More details on data are provided in the next section.

### 5.5.3 The Data and the Econometric Specification

Data were gathered from the official ABC World Airways Guide (ABC WAG) for the month of October 1993 on intra-European duopoly city-pairs or markets. About 380 unidirectional<sup>16</sup> intra-European markets are operated by two carriers, indicating that duopoly is still the dominant market structure in the intra-European airline industry. This is not very surprising since in Europe, despite

<sup>15</sup>It is acknowledged that European airlines fly airplanes of equal comfort, serve similar refreshments and increasingly important, provide comparable frequent flyer programmes.

<sup>16</sup>Travel from point *A* to point *B* is taken as a different market from travel from point *B* to point *A* (see e.g., Borenstein [1990], Berry [1990]).

the EU packages of measures for promoting liberalisation of the industry, most of the international routes are served by the two flag-carriers or some subsidiaries (see Chapter 1). In order to estimate the theoretical (spatial) model analysed in Section 5.3 and Section 5.4, I only consider markets where both duopolists operate the same number of daily aircraft, i.e., symmetric frequencies. This allows me to preserve the symmetrical structure of the model and to focus only on the location pattern (diminishing any bias due to market and/or airport power in the econometric analysis). A sample of 122 unidirectional city-pair markets satisfying the requirement of symmetry is used<sup>17</sup>. In this sample, 4 daily aircraft are operated on 71 markets, 6 daily aircraft are operated on 35 markets, 8 daily aircraft are operated on 8 markets, 10 daily aircraft are operated on 6 markets and finally, 12 daily aircraft are operated on 2 markets. To ensure meaningful observations, the sample includes only markets offering (nonstop) direct services. The minimum daily service level in the sample is 132 passengers and the maximum is 1,968.

The ABC WAG provides a detailed description of the timetable and flight patterns on each market which allows me to construct the *NBOR* dummy variable. In order to understand how this variable is constructed, let us consider the two markets described in Table 5.5.

**Table 5.5: Example of Location Pattern**

<i>Market</i>	<i>Flight Number</i>	<i>Departure Time</i>
MILAN-STUTTGART	LH5347	0745
	AZ452	1110
	LH5343	1650
	AZ1442	2030
STUTTGART-MILAN	AZ1443	0805
	AZ453	1300
	LH5342	1450
	LH5330	2035

Table 5.5 reports the typical daily flight pattern on the Milan-Stuttgart and Stuttgart-Milan markets for the month of October 1993. Both markets are operated by Alitalia (AZ) and Lufthansa (LH) and both flag-carriers operate two daily aircraft on each market. However, it appears from Table 5.5 that on the Milan-Stuttgart route the flights are interlaced (i.e., *NBOR* = 0), while the Stuttgart-Milan route displays a neighbouring flight pattern. In effect, in the latter market Alitalia (AZ) operates the first two (morning) flights while Lufthansa's (LH) flights are scheduled in the afternoon and early evening. When more than 4 flights are provided on a given market, a mixed location pattern may arise resulting in one or more neighbouring flights. For the purpose of the empirical model, mixed locations and neighbouring locations are identically treated since

<sup>17</sup>A potential problem with this sample selection rule is that the sample may suffer from selection bias. The assumptions of the theoretical model, however, prevent me from formally correcting this problem (see e.g., Heckman [1979]).



we have shown in Section 5.4.3 that the equilibrium prices under a mixed location are higher than under an interlaced location. Under the above assumption, 61 observations exhibit a neighbouring location pattern, i.e., half the sample data.

On each route, a number of different fares were available in the ABC WAG, ranging from "First Class" fares to several types of "Discount" fares. The latter category is difficult to consider in an empirical model since the conditions related to the "Discount" fares vary significantly across airlines and markets. Moreover, given that "First Class" services are virtually suppressed in intra-European routes, I focus on the "Economy/Coach" fares<sup>18</sup>. Economy/Coach fares can be considered as the basic price in the airline industry with the other fares being determined as either a mark-up or a discount of economy fares. More importantly for the empirical model, economy fares are considered to be more closely linked to costs<sup>19</sup>. At this point, three remarks are in order. First, on a given market, the basic economy fares as reported by the ABC WAG are the same between airplanes of a given airline. In other words, an airline charges identical fares across its own airplanes. Second, the fares data suggest that duopolists charge very similar fares on a given market<sup>20</sup>. Third, published fares are directional, i.e., they depend on the direction of travel. The above remarks are important in the light of the assumptions used to derive the price equation (5.112).

The main concern of this empirical study is to estimate the price equation (5.112). The specific form chosen is the following log-linear function<sup>21</sup>

$$\begin{aligned} \ln(\text{FARE}/\text{MILE}) = & \alpha_0 + \alpha_1(\text{NBOR}) + \alpha_2\ln(\text{DISTANCE}) + \\ & \alpha_3\ln(\text{PAX}) + \alpha_4\ln(\text{INCORIG}) + \epsilon, \quad (5.113) \end{aligned}$$

where  $\epsilon$  measures independently and identically distributed (i.i.d.) errors in each market and:

*FARE/MILE* = One-way economy fare per mile as reported in the ABC WAG;

*NBOR* = Dummy variable for a neighbouring location pattern;

*DISTANCE* = Airport to airport miles;

*PAX* = Number of daily passenger seats available on a route;

<sup>18</sup>As in the theoretical model, it is assumed that airlines do not price discriminate across passengers. Note also that the use of October data diminishes the typical high season factor that affects pricing in the vacation-oriented routes.

<sup>19</sup>Note that, in my sample data, the correlation between "First Class" fares and "Economy" fares is equal to 0.9496.

<sup>20</sup>In about 70% of the sample data, fares were identical. On average, the difference between duopolists' fares is inferior to 1.5 % (some 6 US\$ on the average fare sample).

<sup>21</sup>The model was estimated in both linear and log-linear forms with similar results. Only the log-linear results are presented in Section 5.5.4, since the estimated coefficients may be readily interpreted as elasticities.

*INCORIG* = Per capita income of the origin city-country (1993 GDP in \$US at market exchange rates).

Except for *PAX*, it is assumed that the explanatory variables in equation (5.113) are exogenous. The *FARE/MILE* variable represents the one-way economy fare (expressed in \$US) per mile. Notice that all fares published in the ABC WAG are expressed in the currency of the country of origin. The IATA Neutral Unit of Construction (NUC) is used to express all fares with a common unit (\$US) and is found in the Currency Conversions section of the ABC WAG. The mileage are airport to airport miles as reported in the Ticketed Point Mileage section of the ABC WAG. With respect to the cost variables, I expect both *DISTANCE* and *PAX* to have significant coefficients. Since the endogenous variable is *FARE/MILE*, I expect the *DISTANCE* variable to have a negative coefficient showing that the average cost per mile falls with distance given the fixed costs of endpoint operations such as take-off and landing. *PAX* is a proxy for the passengers carried *S* given the lack of information of the load factor (*lf*) on a given route (we have that  $S = lf * PAX$ ). Therefore, *PAX* corresponds to the total daily capacity provided by the two duopolists. Information on the type of aircraft used and general aircraft's characteristics are provided in the ABC WAG<sup>22</sup>. The *PAX* variable is expected to have a positive coefficient if carriers face short run capacity constraints. Notice that if marginal cost is falling (due e.g., to economies of traffic density) then the sign could be negative; see the previous section for the interpretation of the coefficient in the price equation (5.106)). The *INCORIG* variable controls for the ability of carriers to charge higher fares if the per capita income is higher in the country of origin, *ceteris paribus*. As an example, given that per capita income is about 10 times larger in England than in Turkey, one would expect duopolists<sup>23</sup> to charge a higher (lower) one-way economy fare in the London-Istanbul (Istanbul-London) market, all other things being equal<sup>24</sup>. Finally, the main motivation of this empirical study is to test for the location pattern hypothesis: I expect the coefficient of the *NBOR* variable to be positive, indicating that the basic economy fare is higher under a neighbouring location pattern, *ceteris paribus*.

Following many empirical studies of airline pricing (see, *inter alia*, Dresner & Tretheway [1992], Abramowitz & Brown [1993], Peteraf & Reed [1994]), the empirical model is estimated using simultaneous two-stage least squares (2SLS) due to the endogeneity of the passengers variable *S* in the price equation (5.112) (or *PAX* in equation (5.113)). Although the demand side modelling is not the primary focus of this work, it is still necessary to control for the factors which

<sup>22</sup>First, note that on most markets, both duopolists use very similar, if not identical, aircraft. Second, assuming a constant load factor across routes and carriers of about 58%, as stated in the AEA Year book for 1993, one would have an estimation of the revenue passengers carried.

<sup>23</sup>In this case, British Airways (BA) and Turkish Airlines (TK).

<sup>24</sup>For a similar argument, see Brueckner, Dyer & Spiller [1992].

affect the output in order to obtain consistent estimates of the price equation. As usual in the case of empirical analysis on transport industries, it is assumed that the market demand is a function of the price and some exogenous variables representing an underlying "gravity model". These latter variables are some measures of the economic size of the two route endpoints and the distance between them. The market demand  $S$  can then be specified in log form as follows

$$\begin{aligned} \ln(PAX) = & \beta_0 + \beta_1 \ln(FARE/MILE) + \beta_2 \ln(AVGPOP) + \\ & \beta_3 \ln(DENSITY) + \beta_4 \ln(DISTANCE) \\ & \beta_5 \ln(RELTRAFTIME) + \varepsilon, \end{aligned} \quad (5.114)$$

where  $\varepsilon$  measures i.i.d. errors in each market and:

*AVGPOP* = The average population of the two route endpoints;  
*DENSITY* = The sum of the aircraft movements at the two endpoints;  
*RELTRAFTIME* = The ratio of train to flight journey time.

The *AVGPOP* variable represents the average population of the two metropolitan areas as stated in the Statesman's Year Book<sup>25</sup>. The *DENSITY* variable is assumed to be a proxy for economic activity at the two route endpoints (income city-specific data are not available). *DENSITY* is calculated as the sum of the weekly departures at the two endpoints cities<sup>26</sup>. I expect to observe that demand rises with both *AVGPOP* and *DENSITY*, i.e., economic size variables. For the *DISTANCE* variable, two contrasting effects are at work. First, large distance implies lower 'attraction' between cities and therefore lower demand. Second, as distance increases, surface transportation is less attractive which should increase air transport demand. So the net effect of *DISTANCE* is hard to predict and has to be determined empirically. Finally, I include the *RELTRAFTIME* variable which controls for intermodal substitution between train and airplane transportation. Because Europe is provided with an extensive rail network and because the average distance is not as great as elsewhere (as, e.g., in the U.S. which is about 1,000 miles compared to some 500 miles in Europe), travelling by train provides an effective alternative to airplane. It is assumed that demand increases as the ratio of train to flight journey time increases. The train journey time is computed using the information available on the Thomas Cook European Timetable, Railway and Shipping Services throughout Europe. The flight journey corresponds to the difference between the scheduled arrival and departure time (ABC WAG).

--

<sup>25</sup>131th Edition, 1994.

<sup>26</sup>Since some cities have several airports, I consider the total departures at the city level.

Table 5.6 (see Appendix on page 177) presents the carriers (with the airline code) and the number of markets in which they appear in the sample data. Notice that all 17 airlines are so-called flag-carriers. Note also that Lufthansa (LH) appears in 43 different (directional) markets, which is the largest number of markets operated by any flag-carrier of the sample data. The main descriptive statistics for the sample data are represented in Table 5.7 (see Appendix on page 178)). The average one way economy fare is 402 \$US, while the average distance is 540 miles. The average scheduled flight time is 104 minutes. Note that the train journey is, on average, some 9 times larger than the flight journey.

In summary, the empirical model is a cross-section study for the month of October 1993. Accordingly, in contrast to previous studies on European airline pricing (Abbott & Thompson [1991], Marin [1995]), the present study does not account for structural changes due to regulatory modifications or different time periods. Data consists of a sample of 122 directional routes. On each market, both duopolists provide the same number of aircraft such that the data satisfy the symmetry requirement of the theoretical model. Finally, the flight pattern has been identified in each market and characterised by the dummy variable *NBOR*.

#### 5.5.4 The Empirical Findings

The objective of the empirical part of the chapter is to provide an estimation of the price equation (5.113). Given the endogeneity of the *PAX* variable, the Instrumental Variable technique (or 2SLS) is performed using Limdep's econometric package. The results of the 2SLS of the price equation (5.113) and the demand equation (5.114) are reported in Table 5.8 (see Appendix on page 179).

The results suggest the following comments. First, *NBOR*, *DISTANCE*, and *INCORIG* all have the expected sign, while *PAX* has a negative and statistically significant sign. Second, the flight location pattern has a significant effect on intra-European airline pricing: The sign of the coefficient for *NBOR* is positive and statistically significant at the 5 % level. This result suggests that, on average, duopolists are able to charge a higher fare under a neighbouring location pattern, all other things being equal. Routes with a neighbouring location pattern have a premium of 0.0689 or about 7 % above fares on routes with purely interlaced location patterns. Third, as shown in the bulk of studies on airline pricing, distance has the greatest effect on fare per mile. A 10 % *DISTANCE*'s increase produces a 3.8 % fare per mile's decrease, *ceteris paribus*. Similarly, a 10 % *INCORIG*'s increase generates a 1 % increase in fare. This latter result is likely to be an important feature of intra-European airline markets. It illustrates carriers' ability to charge higher fares on routes with high income origins. Fourth, the negative sign of the coefficient for the output variable, *PAX*, indicates that a 10 % increase in output generates a 1.8 % decrease in fare (per mile). As mentioned before, the

coefficient for the output variable consists of two distinct effects: (1) A positive demand effect ( $-\partial p^i/\partial S^i$ ) when the aggregate demand is downward sloping and (2) a positive cost effect when carriers operate under short run capacity constraints. Accordingly, a negative coefficient of the output variable could arise if European airlines operate in their declining part of the marginal cost (i.e., under excess capacity and/or due to economies of traffic density), such that the negative effect outweighs the positive demand effect. The strong evidence of the 'persistent overcapacity situation' of European flag-carriers in 1993 (see e.g., AEA Yearbook 1994) tends to support the excess capacity interpretation. Finally, the goodness of fit is high.

The estimates of the output equation of Table 5.8 suggest the following. The coefficients of *AVGPOP* and *DENSITY* have the expected sign. Surprisingly, *FARE/MILE*, *DISTANCE*, and *RELTRAVTIME* have an unexpected, although not statistically significant, sign. The effects of the ratio of train to flight journey time (which controls for intermodal competition) and distance on output are insignificant. Note that the sum of the weekly departures at the two end-points cities (proxy for economic activity at the two route endpoints), measured by *DENSITY*, has the greatest effect on output. As found in other empirical studies, the fit for the output equation is quite poor<sup>27</sup>. Nevertheless, the F statistic suggests that the joint test of the null hypothesis is rejected (the critical value at 1% significance is 3.02).

The next step is to explore whether the empirical results are sensitive with respect to both *DISTANCE* and *RELTRAVTIME* variables. Table 5.9 (see Appendix on page 180) presents the result of the 2SLS model when both *DISTANCE* and *RELTRAVTIME* are omitted. The results of this 'constrained' model show that the exclusion of *DISTANCE* and *RELTRAVTIME* does not affect the price equation's estimates. The change in the estimates of the output equation suggest the following comments. First, the coefficient of the *FARE/MILE* has now the expected negative sign, although still not statistically significant. Second, the coefficients controlling for the economic activity, *AVGPOP* and *DENSITY*, have coefficients of similar magnitude with respect to the 'unconstrained' model. Finally, the goodness of fit of the 'constrained' model is better.

All in all, these results are plausible. Most of the estimated coefficients of economic interest agree with our expectations.

---

<sup>27</sup>This could indicate that a relevant variable is omitted in the output specification. However, it is beyond the scope of the present study to fully explain the output variance.

## 5.6 Concluding Remarks

This chapter first studies the theoretical implications of location patterns in a spatial multiproduct duopoly model. In particular, it addresses the following question: To what extent do location patterns affect firms' pricing behaviour and market performance. Within the Hotelling's [1929] spatial framework, I show that equilibrium prices are higher under a neighbouring location pattern. In other words, noncooperative Nash prices are higher when the organisational market structure is such that firms own strategically dependent outlets. In contrast, I demonstrate that an interlaced location pattern yields the most competitive (Nash) prices. Finally, I also show that social welfare is higher under an interlaced location pattern. These results appear to be robust within the standard assumptions of the spatial model. For example, Bensaid & de Palma [1994] obtain similar results using a two stage location-then-price game. However, it still remains to check the sensitivity of these results to a non uniform demand distribution.

The analysis of a spatial multiproduct (duopoly) model has many potential applications in Industrial Organisation. In a product differentiation interpretation, a neighbouring location pattern arises when each firm specialises on a segment of the 'product line'. In a nonspatial context, a neighbouring location pattern arises when, for example, in a given duopoly market an airline provides all the morning flights and its rival provides all the afternoon flights.

In the second part an empirical model is derived from the theoretical (spatial) model. This methodology allows us to be confident about the predictions on the signs of the regression coefficients. The empirical model explicitly controls for the location pattern effect using data on the intra-European duopoly airline markets.

The principal empirical result suggests that the neighbouring location pattern hypothesis cannot be rejected with data on intra-European airline markets. In effect, after controlling for the principal variables that affect intra-European airline fares, I find that duopoly airline markets experience, on average, higher fares under a neighbouring location. This result has several policy implications. In particular, given that duopoly is the dominant structure in intra-European airline markets, policy-makers and airport authorities should cautiously consider the implications of location patterns for market power and social welfare when awarding slots to competing airlines. Additionally, I find that, on average, European airlines price discriminate according to the income of origin.

The methodology developed in this chapter could be applied in other contexts. The first obvious extension would be to apply it to another scheduling industry. One could test, for example, whether the neighbouring pattern is also a source of market power in the U.S. (deregulated) airline industry. In a purely spatial context, it would be interesting to test the location pattern effect in some retail

industries (e.g., petrol stations around a lake or along a highway). In a product differentiation context, one can think of firms specialised in a segment of the 'product line'. For example in the luxury watch industry, some firms mainly produce 'elegant' watches (e.g., Rolex), while others concentrate on sophisticated 'sports' watches (e.g., Breitling).

The basic empirical model could be extended in two obvious ways. First, Feenstra & Levinsohn [1995] have recently provided a framework to estimate markups and market conduct with multidimensional product attributes. Although the implementation of their econometric model is rather complex, their framework could provide some insight into modelling the airline industry as a multidimensional differentiated industry. Second, an interesting extension when explaining markups would be to allow for two key issues in the European airline industry: Multimarket contact and cross-ownership.

## 5.7 References

- ABC WORLD AIRWAYS GUIDE (ABC WAG), 1993, October, No 712.
- ASSOCIATION OF EUROPEAN AIRLINES YEARBOOK, 1993,1994.
- ABBOTT, K., and THOMPSON, D., 1991, "Deregulating European Aviation: The Impact of Bilateral Liberalization," *International Journal of Industrial Organization*, 9, pp.125-140.
- ABRAMOWITZ, A.D., and BROWN, S.M., 1993, "Market Share and Price Determination in the Contemporary Airline Industry," *Review of Industrial Organization*, 8, pp.419-433.
- BAILEY, E.E., GRAHAM, D.R., and KAPLAN, D.P., 1985, *Deregulating the Airlines*, The MIT Press.
- BAILEY, E.E., WILLIAMS, J.R., 1988, "Sources of Economic Rent in the Deregulated Airline Industry," *Journal of Law and Economics*, 31, pp.173-202.
- BAUMOL, W.J., PANZAR, J.C., and WILLIG, R.D., 1982, *Contestable Markets and the Theory of Industry Structure*, Harcourt, Brace, Jovanovich, San Diego.
- BENSAID, B., and de PALMA, A., 1994, "Spatial Multiproduct Oligopoly," Working Paper No. 1994.8, University of Geneva, April.
- BERRY, S.T., 1990, "Airport Presence as Product Differentiation," *American Economic Review*, 80, pp.394-399.
- BORENSTEIN, S., 1989, "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry," *Rand Journal of Economics*, 20, pp.344-365.

- BORENSTEIN, S.**, 1990, "Airline Mergers, Airport Dominance, and Market Power," *American Economic Review*, 80, pp.400-404.
- BORENSTEIN, S.**, 1991, "The Dominant-Firm Advantage in Multiproduct Industries: Evidence from the U.S. Airlines," *Quarterly Journal of Economics*, 56, pp.1237-1266.
- BRESNAHAN, T.**, 1981, "Departures from Marginal-Cost Pricing in the American Automobile Industry," *Journal of Econometrics*, 17, pp.201-227.
- BRESNAHAN, T.**, 1987, "Competition and Collusion in the American Automobile Industry: The 1955 Price War," *Journal of Industrial Economics*, 35, pp.457-482.
- BRESNAHAN, T.**, 1989, "Empirical Studies of Industries with Market Power," in R. Schmalensee and R. Willig (eds.), *Handbook of Industrial Organization*, Amsterdam: North-Holland.
- BRUECKNER, J.K., and SPILLER, P.T.**, 1994, "Economies of Traffic Density in the Deregulated Airline Industry," *Journal of Law and Economics*, 37, pp.379-415.
- BRUECKNER, J.K., DYER, N.J., and SPILLER, P.T.**, 1992, "Fare Determination in Airline Hub-and-Spoke Networks," *Rand Journal of Economics*, 23, pp.309-333.
- CALL, G.D., and KEELER, T.E.**, 1985, "Airline Deregulation, Fares and Market Behavior: Some Empirical Evidence," in *Analytical Studies in Transport Economics*, A.F. Daughety eds.
- DRESNER M., and TRETHERWAY, M.W.**, 1992, "Modelling and Testing the Effect of Market Structure on Price," *Journal of Transport Economics and Policy*, 26, pp.171-184.
- DRESNER, M., and WINDLE, R.**, 1992, "Airports Dominance and Yields in the U.S. Airline Industry," *Logistics and Transportation Review*, 28(4), pp.319-339.
- ENCAOUA, D.**, 1991, "Liberalizing European Airlines: Cost and Factor Productivity Evidence," *International Journal of Industrial Organization*, 9, pp.109-124.
- ENCAOUA, D.**, 1991, "Regulatory Reform and Liberalization: A European Perspective," *International Journal of Industrial Organization*, 9, pp.1-7.
- EVANS, W.N., and KESSIDES, I.N.**, 1993a, "Structure, Conduct, and Performance in the Deregulated Industry," *Southern Economic Journal*, 59, pp.450-467.



- EVANS, W.N., and KESSIDES, I.N.,** 1993b, "Localized Market Power in the U.S. Airline Industry," *Review of Economics and Statistics*, 75, pp.66-75.
- FEENSTRA, R.C., and LEVINSOHN, J.A.,** 1995, "Estimating Markups and Market Conduct with Multidimensional Product Attributes," *Review of Economic Studies*, 62, pp.19-52.
- GABSZEWICZ, J.J., and THISSE, J.-F.,** 1986, "Spatial Competition and the Location of Firms," in Gabszewicz, Thisse, M. Fujita and U. Schweizer, *Location Theory, Fundamentals of Pure and Applied Economics* (eds), Hardwood Academic Publishers, Chur (Switzerland).
- GRAHAM, D.R., KAPLAN, D.P., and SIBLEY, D.S.,** 1983, "Efficiency and Competition in the Airline Industry," *Bell Journal of Economics*, 14, pp.118-138.
- GREENHUT, M.L., NORMAN, G., and HUNG, C.-S.,** 1987, *The Economics of Imperfect Competition: A Spatial Approach*, Cambridge University Press.
- HECKMAN, J.J.,** 1979, "Sample Selection Bias as a Specification Error," *Econometrica*, 47, pp.153-161.
- HOTELLING, H.,** 1929, "Stability in Competition," *Economic Journal*, 39, pp.41-57.
- HURDLE, G., JOHNSON, R., JOSKOW, A., WERDEN, G., and WILLIAMS, M.,** 1989, "Concentration, Potential Entry, and Performance in the Airline Industry," *Journal of Industrial Economics*, 38, pp.119-139.
- JOSKOW, A.S., WERDEN, G. J., and JOHNSON, R.L.,** 1994, "Entry, Exit, and Performance in Airline Markets," *International Journal of Industrial Organization*, 12, pp.457-471.
- LEVINE, M.E.,** 1987, "Airline Competition in a Deregulated Market: Theory, Firm Strategy, and Public Policy," *Yale Journal on Regulation*, 4, pp.393-494.
- MARIN, P.L.,** 1995, "Competition in European Aviation: Pricing Policy and Market Structure," *Journal of Industrial Economics*, 43, pp.151-159.
- MARTINEZ-GIRALT, X., and NEVEN, D.,** 1988, "Can Price Competition Dominate Market Segmentation?," *Journal of Industrial Economics*, 36, pp.431-442.
- MORRISON, S.A., and WINSTON, C.,** 1989, "Enhancing the Performance of the Deregulated Air Transportation System," *Brookings Papers on Economic Activity*, pp.61-123.

- MORRISON, S.A., and WINSTON, C.,** 1990, "The Dynamics of Airline Pricing and Competition," *American Economic Review*, 80, pp.389-393.
- OUM, T.H., ZHANG, A., and ZHANG, Y.,** 1993, "Inter-Firm Rivalry and Firm-Specific Price Elasticities in Deregulated Airline Markets," *Journal of Transport Economics and Policy*, 27, pp.171-192.
- PANZAR, J.C.,** 1979, "Equilibrium and Welfare in Unregulated Airline Markets," *American Economic Review*, 69, pp.92-95.
- PETERAF, M.A., and REED, R.,** 1994, "Pricing and Performance in Monopoly Airline Markets," *Journal of Law and Economics*, 37, pp.193-213.
- REISS, P.C., and SPILLER, P.T.,** 1989, "Competition and Entry in Small Airline Markets," *Journal of Law and Economics*, 32, pp.S179-S202.
- TIROLE, J.,** 1988, *The Theory of Industrial Organization*, Cambridge: The MIT Press.

## 5.8 Appendix

Table 5.6: Airlines and Markets in the Data Set

<i>Airline</i>	<i>Markets</i>
AIR FRANCE (AF)	28
AIR PORTUGAL (TP)	4
ALITALIA (AZ)	28
AUSTRIAN AIRLINES (OS)	9
BRITISH AIRWAYS (BA)	28
CZECHOSLOVAK AIRLINES (OK)	4
FINNAIR (AY)	4
IBERIA (IB)	20
KLM (KL)	10
LUFTHANSA (LH)	43
LUXAIR (LG)	4
MALEV (MA)	3
OLYMPIC AIRWAYS (OA)	2
SABENA (SN)	16
SAS (SK)	15
SWISSAIR (SR)	22
TURKISH AIRLINES (TK)	6

Table 5.7: Descriptive Statistics, Obs=122

<i>Variable</i>	<i>Mean</i>	<i>Std Dev.</i>	<i>Minimum</i>	<i>Maximum</i>
ECONOMY FARE (One-way, \$US)	402.4	139.2	138.30 (BRU-AMS)	838.90 (CDG-IST)
DISTANCE (Mile)	540	295	98 (BRU-AMS)	1'552 (LON-IST)
FARE/MILE (\$US/Mile)	0.8645	0.2915	0.302 (LON-IST)	1.672 (STR-LIN)
PAX	632	342	132 (ZRH-BRE)	1'968 (LIN-CDG)
AVGPOP	1,385,000	840,800	244,600 (ZRH-SZG)	4,398,925 (LON-IST)
DENSITY (Departures)	3,997	1,529	1,476 (VIE-PRG)	7,443 (FRA-CDG)
TRAIN TIME (Minute)	1,034	709	180 (AMS-BRU)	4,200 (LON-IST)
FLIGHT TIME (Minute)	104	35	45 (AMS-BRU)	230 (LON-IST)
RELTRAVTIME	9.2	3.7	4 (AMS-BRU)	18.3 (LON-IST)
INCORIG (\$US)	22,310	7,362	1,914 Turkey	34,962 Switzerland
NBOR	0.5	0.5021	0	1

Table 5.8: 2SLS Coefficient Estimates (Model I), Obs=122

Dependent Variable: $\ln(\text{FARE}/\text{MILE})$	Coefficient	Std.Error	t-value
<i>INTERCEPT</i>	2.2286	0.4784	4.658
<i>NBOR</i>	0.068936	0.03545	1.945
$\ln(\text{DISTANCE})$	-0.38146	0.03845	-9.921
$\ln(\text{PAX})$	-0.17923	0.06989	-2.565
$\ln(\text{INCORIG})$	0.10197	0.03016	3.381
Std. Dev. of Residuals	0.1856404		
Sum of Squares	4.032097		
R-squared	0.687318		
Adjusted R-squared	0.676628		
F[4,117]	64.29552		
Log-likelihood	34.88329		
Dependent Variable: $\ln(\text{PAX})$	Coefficient	Std.Error	t-value
<i>INTERCEPT</i>	-3.5783	3.375	-1.060
$\ln(\text{FARE}/\text{MILE})$	0.77293	0.8369	0.924
$\ln(\text{AVGPOP})$	0.18067	0.09352	1.932
$\ln(\text{DENSITY})$	0.80495	0.1366	4.429
$\ln(\text{DISTANCE})$	0.42841	0.3178	1.348
$\ln(\text{RELTRAVTIME})$	-0.032426	0.1715	-0.189
Std. Dev. of Residuals	0.4402385		
Sum of Squares	22.48195		
R-squared	0.2852232		
Adjusted R-squared	0.2544139		
F[5,116]	9.257686		
Log-likelihood	- 69.9407		

Table 5.9: 2SLS Coefficient Estimates (Model II), Obs=122

Dependent Variable: $\ln(\text{FARE/MILE})$		Coefficient	Std.Error	t-value
<i>INTERCEPT</i>		2.2286	0.4784	4.658
<i>NBOR</i>		0.068936	0.03545	1.945
$\ln(\text{DISTANCE})$		-0.38146	0.03845	-9.921
$\ln(\text{PAX})$		-0.17923	0.06989	-2.565
$\ln(\text{INCORIG})$		0.10197	0.03016	3.381
Std. Dev. of Residuals		0.1856404		
Sum of Squares		4.032097		
R-squared		0.687318		
Adjusted R-squared		0.676628		
F[4,117]		64.29552		
Log-likelihood		34.88329		
Dependent Variable: $\ln(\text{PAX})$		Coefficient	Std.Error	t-value
<i>INTERCEPT</i>		-0.22617	1.271	- 0.178
$\ln(\text{FARE/MILE})$		-0.11189	0.1781	0.628
$\ln(\text{AVGPOP})$		0.14822	0.08245	1.798
$\ln(\text{DENSITY})$		0.54205	0.1125	4.819
Std. Dev. of Residuals		0.4285485		
Sum of Squares		21.67115		
R-squared		0.3226793		
Adjusted R-squared		0.3054593		
F[3,118]		18.73862		
Log-likelihood		- 67.70011		













