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THE
ECONOMIC EFFECT OF COMPETITION
IN THE
AIR TRANSPORTATION INDUSTRY

by

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Abstract

The air transportation industry has been described as a highly-competitive, regulated oligopoly or as a price-regulated cartel with blocked entry, resulting in excessive service and low load factors. The current structure of the industry has been strongly influenced by the hypotheses that increased levels of competition are desirable per se, and that more competing carriers can be economically supported in larger markets, in longer-haul markets, with lower unit costs, and with higher fare levels. An elementary application of competition/game theory casts doubt on the validity of these hypotheses, but rather emphasizes the critical importance of the short-term non-variable costs in determining economic levels of competition.

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by Herbert B. Hubbard, United Air Lines

Introduction

Airlines are regulated and controlled by the government as public utilities because their services are deemed essential from the public standpoint and, accordingly, must be rendered efficiently. Furthermore, the economies of large-scale production and decreasing unit costs tend to increase the size of the business unit, and government regulation is designed to prevent the potential attendant unreasonable or unfair rates or inferior or inadequate service. However, unlike most other public utilities, few airlines enjoy monopoly situations with exclusive franchises for a number of years. Airlines are highly-regulated public utilities, but are also highly competitive.

Economists have defined airlines as "a blocked-entry, price-controlled, non-price-competing cartel," or as highly competitive but regulated oligopolies, with their products essentially undifferentiated, with entry of new competitors into a market difficult because of the entrance fee in terms of government regulation and capital costs, and in which the actions of each competitor (who supplies significant portions of the total product) can have a marked effect on the plans and actions of the other competitors. The classical economic theories for monopolies and pure competition do not apply to the air transportation industry, because there are generally more than one competitor in a market, but there are only a limited number of competitors. However, the economic situation of the airlines (that is, the imperfect competition of oligopolies) lends itself less easily to theoretical analyses than do monopolies and pure competition.

It is the purpose of this paper to investigate the economic effect of competition in the air transportation industry in terms of the efficient allocation of resources. The paper will include a discussion of competition, certain basic economic factors in the industry, the types of scheduling decisions made, the importance of flight share in determining market share, an illustration of the application of competition/game theory by means of a simplified example, and a summary of the apparent results of competition with conclusions. The derivation of the various mathematical relationships are included in the appendices.

COMPETITION

Competition is considered to be healthy and desirable in the American economy. There is competition in the transportation industry (1) between the various segments or modes of the industry and (2) within the various segments as certificated by governmental agencies. In the first case, we have a "natural" variety of competition in which technological improvements are paramount and which often results in substantial benefits to the public in the form of improved service and/or lower rates. On the other hand, the second type of competition, with multiple (more than 2 or 3) competitors, has tended to depress the economic viability of the carriers with negligible benefits to the public.

The expansion of route awards in the air transportation industry has made the government policy in this area well known. The amount of competition among the airlines has been increased substantially during recent years. In most cases, the Civil Aeronautics Board has not recognized nor fully considered the probable impact of such awards on the economic viability of the established carriers.

There is a fundamental question as to the amount of competition within the air transportation industry that is desirable and supportable from an economic efficiency point of view:

Federal Aviation Act, Section 102 — Declaration of Policy

> "....the Board shall consider....as being in the public interest.... Competition to the extent necessary to assure the sound development of an air transportation system....without....unfair or destructive competitive practices."

Bermuda Capacity Principles

> "....strong adherence of the United States....authorizing designated carriers to conduct their operations without predetermined limits on capacity, but subject to ex post facto review to require elimination of unjustified capacity....other countries are less enamored of the Bermuda capacity principles and wish to follow more restrictive policies than we in controlling capacity and scheduling."

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C.A.B. Statement in the Southern Service to the West Case (1951)

> "....accumulated experience strongly suggests that we may have reached, and in some cases even exceeded, the optimum number of certificated services that can be economically supported by the available traffic."

Honorable Charles S. Murphy, Chairman, C.A.B., November 16, 1967

> "....the American economy is generally a competitive economy. For the most part, we depend upon free competition among private business enterprises to achieve the most efficient use of resources.... belief that vigorous competition is a good thing — even in the airline industry."

Honorable Secor D. Brown, Chairman, C.A.B., August, 1970

> "The cardinal sins of the regulators have been in legislating, in effect, wasteful, ruinous over-competition along our routes and then intervening unwisely to forestall the natural adjustments for over-competition — merger, statesmanlike agreement, or business failure."

Critical Hypotheses

There appear to be several hypotheses that gained rather wide acceptance among members within the industry and among observers and analysts of the industry, and that have influenced the current structure of the industry and level of competition:

1. Increased levels of competition are deemed desirable per se.
2. More competing carriers can be economically supported:
   a. In larger passenger markets (in terms of passengers per day),
   b. In longer-haul markets (with greater revenues per passenger),
   c. With lower unit costs (in terms of cents per available seat mile),
   d. With higher fare levels (in terms of cents per revenue passenger mile), and,
   e. With newer technology (with resulting economies of scale).
3. Increases in market share will result in greater profits.

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BASIC ECONOMIC FACTORS

An evaluation of the air transportation industry must recognize economies of scale, the lumpiness (large incremental step-functions) of various types of costs, and marginal analysis for determining the efficient economic allocation of resources.

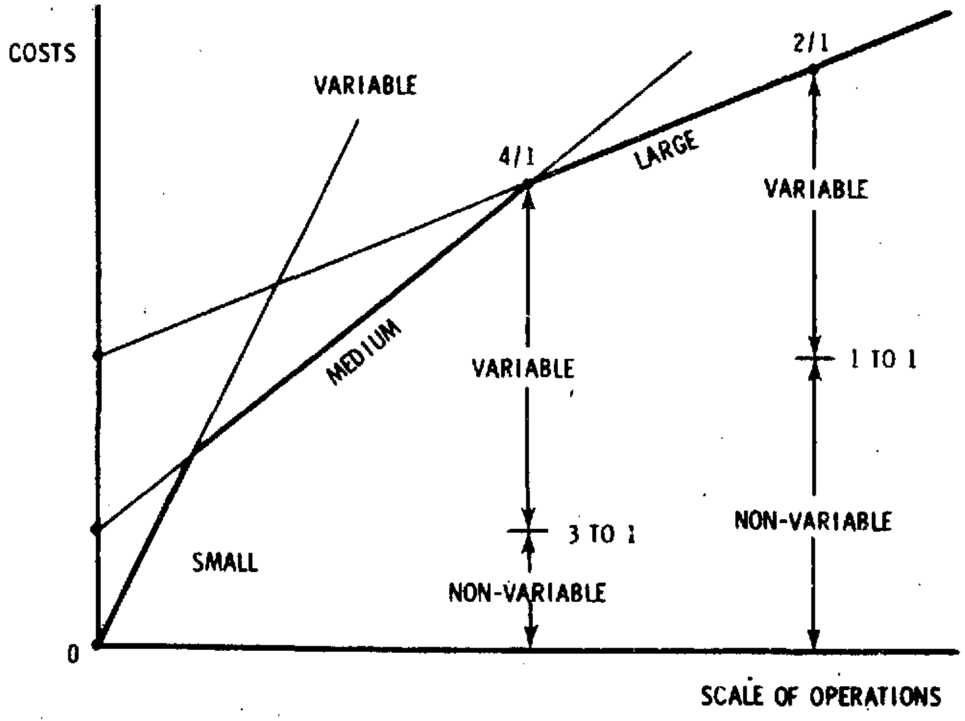

CHART 1

Economies of Scale

Chart 1 shows a theoretical variation in total costs as a function of the scale of operations. A small firm might have essentially no fixed costs but relatively high variable costs. A medium-sized firm may have some non-variable fixed costs and, as a result, somewhat lower variable costs, in which the total variable costs might be three times the non-variable costs, or, in other words, the total costs might be four times the total non-variable fixed costs. An even larger firm might have significantly higher non-variable fixed costs, with even lower unit variable costs such that the total costs might be only two times the non-variable fixed costs. These relationships show a decreasing total unit cost with increasing scale of operation.

Because various costing methodologies tend to be rather subjective, it is difficult to categorize certain costs as totally variable and others as completely fixed or non-variable in the short term of six months to one year. (Over the longer term, all costs must be considered as variable.) However, in contrast to some economists' contentions, our analyses and detailed costing models have shown the above economies of scale (decreasing unit costs) with great accuracy for United and other carriers, with total costs ranging from 2 to 3 times the non-variable fixed costs. (Such economies of scale have led to the establishment of "natural" monopolies in other industries.)

Lumpiness of Costs

There are four different levels of costs which must be recognized: costs per unit, costs per production lot, costs for capital equipment, and overhead costs. Certain airline costs tend to vary directly with the volume of passengers served (i.e., tickets, meals, insurance, reservations costs, etc.) and can be handled as a deduction to obtain the net fare yield per passenger. Other costs are quite lumpy, such as the marginal operating costs for a given flight (principally fuel, crew, and direct maintenance costs) which are essentially independent of the passenger loads. The capital costs of the equipment vary with the number of airplanes, each of which is used on one or more trips per day. Other airline costs are established on the basis of the planned scale of operations and do not vary with individual scheduling decisions.

Marginal Analysis

For economic efficiency, a firm should expand its volume of operations until the marginal revenues just equal marginal cost, in order to maximize its profits or minimize its losses, as shown in Chart 2.

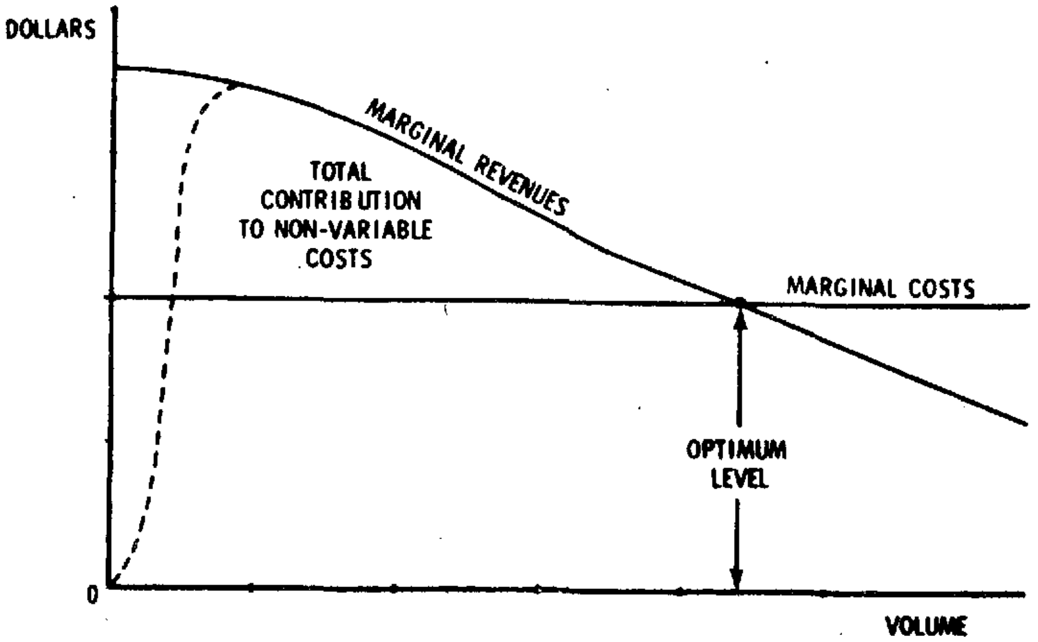

CHART 2

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Although a certain minimum volume of operations might be required to realize the marginal revenue curve shown, the area between the marginal revenue line and the marginal cost line represents the total contribution to non-variable costs. It should be noted that the marginal cost curve has not been assumed to turn up with increasing volumes in accordance with the classical economists' theory, but rather shows no dis-economies of scale.

SCHEDULING DECISIONS

Analyses have shown that the basic schedule pattern for an airline determines 80-90% of its revenues, determines 70-90% of its costs, and also establishes 85-95% of its total capital investment. The basic schedule pattern is established on the basis of a series of scheduling decisions for all of the various airport-pair time markets, together with their interrelationships. For the purpose of simplification, but without distorting the basic factors, there are really only three types of scheduling decisions for an airport-pair time market:

1. Decision to add or subtract a flight, which is an integer number. (It is relatively easy to add a flight in a market, but quite difficult to reduce service, in view of various community pressures.)
2. Decision to change the type of airplane providing the service.
3. Decision to move a flight earlier or later during the day.

MARKET SHARE

Accurate forecasts of market share are essential for the schedule planning and equipment purchase decisions, and for the resulting workforce planning, facilities planning, etc. Experience has shown that an increase in frequency in a major competitive market is generally accompanied by an increase in market share and an attendant increase in revenue. In fact, frequency of service is probably the strongest competitive tool in the airlines' "bag of tricks.'

A carrier in search of an increased part of the total industry revenues may act in a rational manner by adding one flight on a segment. His competitors, seeing their share of the market slip and their revenues decline, may act in an equally rational manner by adding one flight in an attempt to retain their market share and profits. After some "settling" time, each carrier could be back to its original market share, so that its operating revenues would be unchanged. However, each carrier would have increased its operating costs by the expense of the additional flight. It can been seen that by changing a relatively stable two-carrier market into a three, four, and sometimes five-carrier market, it becomes more volatile, with the possibility that one carrier will set off a chain-like reaction.

The increase in frequency (capacity and costs), with a resulting reduction in load factor, due to the competitive nature of the industry has been explained by Mr. Joseph V. Yance, consultant to the Office of the Secretary of Transportation (CAB Docket 21866-6, Exhibit DOT-RT-1, pages 6 and 7):

> "As we noted earlier, American, United, and TWA argue that the number of competitors in a market has an impact on load factors. In general, the more competitors in a market, the lower the load factors of carriers serving that market. Our theoretical analysis of carrier behavior supports this view.
>
> "The reasoning is as follows. What is critical to an airline in making its schedule decision is the number of "new passengers" attracted by an additional flight. (By "new passengers," we mean passengers the airline is not already carrying on its existing flights.) In either a monopoly or a competitive market, the number of new passengers required to sustain a flight is the same. But the relation between new passengers and average load on board varies significantly between the two types of markets. In a monopoly market, apart from passengers who are flying because of the additional service and who would not fly absent such new service, all of the passengers on board a new flight are drawn from other flights of the (same) airline; hence unless the number of persons who would first fly because of the new service is large enough to cover the costs of a new flight, the flight will not be added.
>
> "The situation is very different in a competitive market. There, new passengers will consist of (1) those persons first traveling because of the additional service (as in the case of a monopoly market), and (2) passengers diverted from existing flights of other airlines. It may thus be profitable for a carrier to add a flight, even though overall load factors in the market decline. On the basis of this analysis, one cause for the decrease in load factors one observes over time is the increasing competitiveness of markets."

"S" Curve Relationships

Many analyses have been made to relate the market share (or percentage participation in the total passenger market) to the flight share (or relative number of flights per day), as shown in Chart 3. The relationship line will obviously pass through the origin and the (100,100) end point, and in a two-carrier market, will generally pass through the (50,50) point. Some analysts have concluded that there is an "S"-shaped curve effect, since a majority of the points in the 15-35% range are below the diagonal regression line, while a majority of the points in the 65-90% range are above it. Such an "S"-shaped curve would imply that the carrier with the highest frequency share would get a disproportionate market share, and that therefore the way to make greater profits is to be the schedule leader. Such reasoning might lead a carrier to emphasize market share and growth to the neglect of the profit objective.

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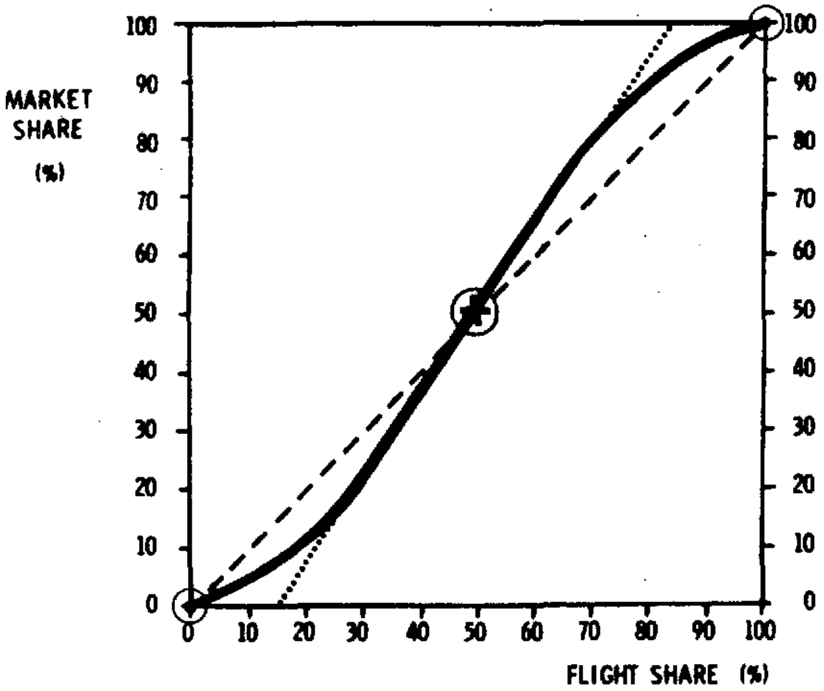

CHART 3

The Civil Aeronautics Board released on July 21, 1970 (CAB 70-96, 382-6031), the first of a projected series of staff studies evaluating route awards made by the Board in recent years. It was their first attempt to determine whether the carriers have actually performed in accordance with the anticipation and intent of the Board. Some of the conclusions reached in the pilot study included:

> "2. The total number of flights and the proportionate share of non-stop flights were greater under competition.
>
> "4. There appears to be generally a close relationship between the share of flights provided by each carrier and the share in traffic."

In order to analyze the effect of competition, it is not necessary to assume an "S"-shaped curve but to merely recognize that a change in the frequency share by one carrier will effect its market share. High correlation coefficients in the regressions of market share against flight share have been interpreted as proving the validity of the "S" shape. However, in most analyses, the regression hypothesis is actually whether greater frequency means greater market share, not whether greater frequency means a disproportionate market share.

Linear Regression Analysis

As part of United's rebuttal testimony in Phase 6 of the General Domestic Passenger Fare Investigation (Docket 21866-6, Exhibits UR-T-1, pages 12 and 13, and Exhibits UR-8 and 9), the results of a linear regression analysis of all of the basic data contained in the C.A.B. Bureau of Economics Exhibits BE 6502 (Columns 8 and 10) for all competitive sample markets were summarized:

Market Share = 1.09 x Flight Share - 3.7
(in %) (in %)

280 Observations*

Coefficient of Determination (R^2) = 91.4% of Total Variance

Standard Error of Estimate = 6.48 percentage points

F level = 30.05

* In order to avoid the inherent auto-correlation among the data for all carriers in a market, only one data point was used for a two-carrier market, two data points for a three-carrier market, etc.

These results show the extremely high correlation which actually exists between market share and flight share, based on the extensive basic data assembled by the C.A.B. Bureau of Economics. Furthermore, an analysis made of the exceptional variances, between the actual and the predicted values for the various city-pair markets included in the regression analysis, highlighted the practical aspects of on-line, through, and connecting service and the factor of market identity. By recognizing these differences, the relationship between market share and flight share would have become even greater than that indicated in the correlation analysis. It would be very difficult to improve these simple linear regression results (with a nominal threshold value) by more complicated and sophisticated curvilinear relationships to approximate the "S" curve. Accordingly, the following analysis is based initially on the simple diagonal relationship (that is, market share = flight share), and later extended to cover a linear regression with a threshold value and a possible curvilinear relationship.

BASIC ASSUMPTIONS

The following competition/game theory analysis is based on two basic assumptions:

1. There is no collusion, overt or tacit, among competitors.

2. Each carrier purchases and schedules equipment in its own self-interest, i.e.:

   a. Each carrier expands its production (schedules) up to the limit of capacity whenever marginal revenues exceed marginal costs, and,

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b. Each carrier purchases additional equipment if the marginal contribution exceeds marginal capital costs.

The second assumption would preclude an airline from seeking growth or increased market share at the expense of profit.

EXAMPLE OF COMPETITION

The following simplified example is based on a reasonably typical airport-pair time market:

Potential Market (If 3 or More Flights)	200 passengers per day
Net Fare Yield	$67.20 per passenger
Airplane Seating Capacity	100 seats
Variable Costs	$1,400 per flight

By simple arithmetic, it can be seen that if this were a monopoly market with only Airline "A" certificated, that carrier would probably operate three (or possibly four) flights.

	3 Flights	4 Flights
Revenues Per Day	$13,440	$13,440
Variable Costs Per Day	4,200	5,600
Net Contribution Per Day	$ 9,240	$ 7,840
Passenger Load Factor	67%	50%

Two Carriers

If Airline "B" were to be certificated as a new competitor in this market, with three flights already operated by Airline "A", it would be faced with the marginal economic analysis shown in Chart 4, based on the direct diagonal relationship of market share against flight share. For example, if Airline "B" operates one flight out of a total of four flights, the marginal revenue for that flight would be one-fourth x $13,440, or $3,360. Airline "B", accordingly, would probably operate two flights in the market, because the total contribution for these two flights would be $2,580 per day, $60 greater than if it operated three flights.

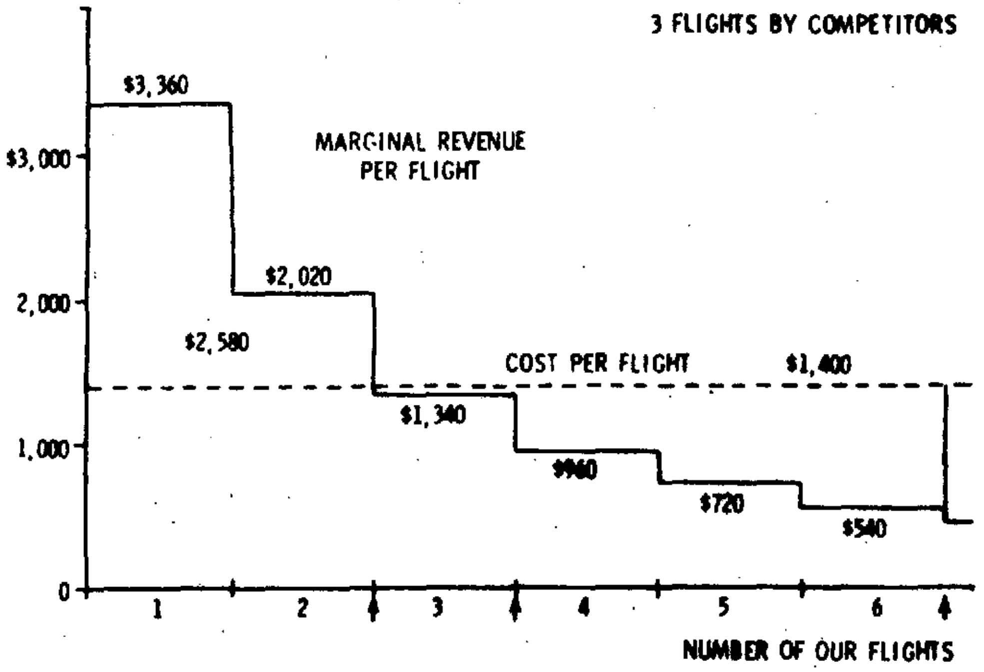

CHART 4

However, Airline "A" would now find that its contribution from the market could be increased by $60 if it cut back to two flights per day. The net result would be four flights in the market (two by "A" and two by "B"), with an average passenger load factor of 50%. However, if each airline hoped to increase its share of the market from 50% to 60% at a daily cost of $60, the net result might be six flights in the market (three by "A" and three by "B"), with an average passenger load factor of 33% and with each airline realizing $1,400 per day less contribution than if each airline operated only two flights in the market. Chart 4 also demonstrates graphically the potential impact of attempting to increase market share at the expense of profit.

Three Carriers

If a third carrier, Airline "C", were to be authorized, with four flights already serving the market (two by "A" and two by "B"), Airline "C" would operate at least one flight with a contribution of $1,290 per day, but probably two flights with a total contribution of $1,680 per day. A third flight by "C" would have a negative contribution. Neither "A" nor "B" could improve its own contribution by either increasing or decreasing its frequency. The net result would be six flights in the market (two each by "A", "B", and "C"), with an average passenger load factor of 33%.

Four Carriers

In a similar manner, the authorization of a fourth airline, "D", would tend to result in eight flights in the market, with an average load factor of 25% and a contribution of only $560 per airline, which probably would be inadequate to cover the allocated capital costs and those cost factors not directly related to this market.

Scheduling Strategy

Chart 5 illustrates the results of various scheduling strategies for the example case, based on the simplified (and most favorable) relationship that market share equals flight share.

Market Share
Revenue
Cost
Contribution
P.L.F.

MARKET SHARE = FLIGHT SHARE

		NUMBER OF FLIGHTS BY COMPETITORS						
		0	**1**	**2**	**3**	**4**	**5**	**6**
NUMBER OF OUR FLIGHTS	**1**	100% $ 5,040 -1,400 $ 3,640 75%	50% $ 5,040 -1,400 $ 3,640 75%	33% $ 4,480 -1,400 $ 3,080 67%	25% $ 3,360 -1,400 $ 1,960 50%	20% $ 2,690 -1,400 $ 1,290 40%	17% $ 2,240 -1,400 $ 840 33%	14% $ 1,920 -1,400 $ 520 29%
	2	100% $10,080 -2,800 $ 7,280 75%	67% $ 8,960 -2,800 $ 6,160 67%	50% $ 6,720 -2,800 $ 3,920 50%	40% $ 5,380 -2,800 $ 2,580 40%	33% $ 4,480 -2,800 $ 1,680 33%	29% $ 3,840 -2,800 $ 1,040 29%	25% $ 3,360 -2,800 $ 560 25%
	3	100% $13,440 -4,200 $ 9,240 67%	75% $10,080 -4,200 $ 5,880 50%	60% $ 8,060 -4,200 $ 3,860 40%	50% $ 6,720 -4,200 $ 2,520 33%	43% $ 5,760 -4,200 $ 1,560 29%	37% $ 5,040 -4,200 $ 840 25%	33% $ 4,480 -4,200 $ 280 22%
	4	100% $13,440 -5,600 $ 7,840 50%	80% $10,730 -5,600 $ 5,130 40%	67% $ 8,960 -5,600 $ 3,360 33%	57% $ 7,680 -5,600 $ 2,080 29%	50% $ 6,720 -5,600 $ 1,120 25%	44% $ 5,970 -5,600 $ 370 22%	40% $ 5,380 -5,600 $ -220 20%

CHART 5

The horizontal rows, for various number of flights that we might operate, show the results when faced by various number of flights operated by our competitor(s). The entries in each box show our market share, our resulting revenue based on that market share, our variable costs at $1,400 per flight, our contribution from the market, and the passenger load factors for our flights and for the industry. For example, if we expect our competitors to operate four flights, our greatest contribution from the market would be $1,680 by our operating two flights.

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The results for the industry may be summarized as follows:

Market Revenues	$13,440 per day
Variable Costs	$ 1,400 per flight

Number of Carriers (Q)	1	2	3	4
Flights/Carrier	3	2	2	2
Total Flights	3	4	6	8
Passenger Load Factor	67%	50%	33%	25%
Industry Revenues	$13,440	$13,440	$13,440	$13,440
Industry Costs	4,200	5,600	8,400	11,200
Industry Net	$ 9,240	$ 7,840	$ 5,040	$ 2,240

This summary can be extended to show the industry profits resulting if the variable costs represent only 67% or 50% of the total costs:

If Variable = 67% Total Costs				
Non-Variable Charge	2,100	2,800	4,200	5,600
Industry Profit	$ 7,140	$ 5,040	$ 840	$-3,360
If Variable = 50% Total Costs				
Non-Variable Charge	4,200	5,600	8,400	11,200
Industry Profit	$ 5,040	$ 2,240	$-3,360	$-8,960

For this illustrative airport-pair time market, four competitors would incur significant losses and three competitors would have either inadequate returns on their investments or losses.

COMPETITION THEORY

The results of the simplified example can be generalized by the use of microeconomic analysis combined with an elementary form of competition/game theory. However, this application is really not the classical game theory, as developed by J. Von Neumann and Oskar Morgenstern, but rather is derived by the simple application of high school partial differential equations. Appendix A-1 shows that if each carrier adds flights as long as the marginal revenues equal or exceed the marginal cost, and if the market share equals the flight share:

$$\left(\begin{array}{c}\text{Optimum Number}\\ \text{of Flights for}\\ \text{Each Carrier}\end{array}\right) = \frac{\text{(Industry Market Revenues)}}{\text{(Variable Costs Per Flight)}} \quad \text{X} \quad \left(\frac{Q - 1}{Q^2}\right)$$

$$\text{For } Q = 2, \quad \left(\frac{Q - 1}{Q^2}\right) = \frac{1}{4}$$

$$\text{For } Q = 3, \quad \left(\frac{Q - 1}{Q^2}\right) = \frac{2}{9}$$

$$\text{For } Q = 4, \quad \left(\frac{Q - 1}{Q^2}\right) = \frac{3}{16}$$

In this relationship, Q represents the number of equal competitors in a particular airport-pair time market, with equal drawing power for each competitor's flights. The industry market revenues per day are available to all competitors in the market. In the short term, the variable costs per flight might represent only the costs for fuel, crew, and direct maintenance, but over the longer term would have to include the capital costs for additional equipment. This equation also assumes that the industry market revenue forecasts made at the time of equipment purchase actually materialize when the equipment is placed into service. If not, the number of trips scheduled will exceed the optimum number, making the resulting contributions and profits lower than this equation would suggest.

Application of the above equation to the illustrative example results in the following comparison of the theoretical optimum number of flights for each carrier versus the number determined previously:

	Number of Carriers (Q)			
	1	2	3	4
Equation: $\frac{\$13,440}{\$\ 1,440} \text{ X } \frac{Q - 1}{Q^2}$	-	2.4	2.1	1.8
As Determined Previously In Example	3	2	2	2

Total Industry Relationships

Appendix A-2 extends the above relationship to the total industry by simple algebraic manipulation:

- $$\text{Total Flights} = \frac{(\text{Industry Market Revenues})}{(\text{Variable Costs Per Flight})} \times \left(\frac{Q - 1}{Q}\right)$$

$$\text{Total Costs} = g \times (\text{Industry Market Revenues}) \times \left(\frac{Q - 1}{Q}\right)$$

$$\text{Where} \quad g = \frac{(\text{Total Costs})}{(\text{Variable Costs})}$$

$$\text{Operating Ratio} = g\left(\frac{Q - 1}{Q}\right)$$

- $$\text{Profit Margin} = 1 - g\left(\frac{Q - 1}{Q}\right)$$

- $$\text{For Breakeven} \quad g\left(\frac{Q - 1}{Q}\right) \equiv 1$$

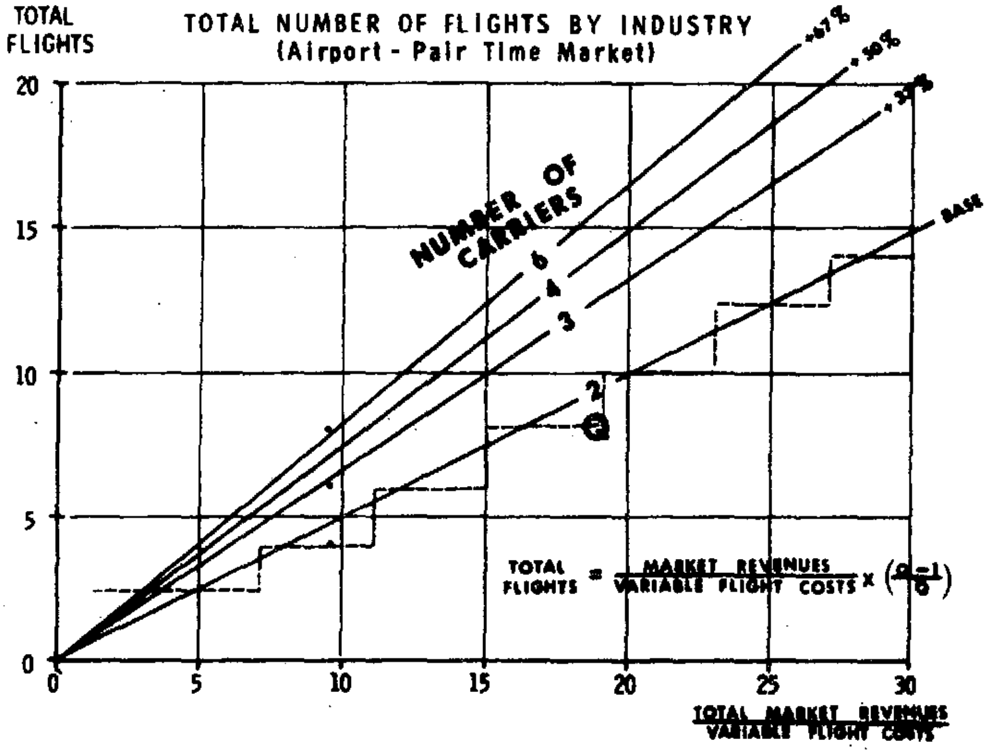

CHART 6

Total Industry Flights

Chart 6 shows the total number of industry flights as a function of the ratio of total market revenues to variable costs per flight for various numbers of carriers in an airport-pair time market. It can be seen that the total number of industry flights tends to vary directly with the market size and fare level, and varies inversely with the variable costs per flight. It also increases with the number of carriers. However, it will tend to follow a stepped function because of the requirement of an integer number of flights by each carrier.

The service to the traveling public may be improved by the increased number of flights, but it should be recognized that the costs and capital investments vary also with the increased number of flights, resulting in a deterioration of the return on investment for each carrier. Similarly, the actual passenger load factor realized will be decreased with an increased number of competitors.

On the other hand, the service to the traveling public may not be improved with an increase in the number of competitors. A monopoly carrier could provide good service with five flights, spaced at desirable departure times throughout the day; whereas three carriers in the same market might operate three flights each for a total of nine flights, but with three competing flights peaked at the three largest-demand periods of the day, since this can be shown to be the "best" strategy for each competing carrier.

Profit Margin

Chart 7 shows that the profit margin for the industry is a function of the ratio of total costs to variable costs and the number of carriers, covering a representative range of values.

$$\text{PROFIT MARGIN} = 1 - \left(\frac{\text{TOTAL COSTS}}{\text{VARIABLE COSTS}}\right)\left(\frac{Q-1}{Q}\right)$$

WHERE Q - NUMBER OF CARRIERS CERTIFICATED

TOTAL COSTS/VARIABLE COSTS	NUMBER OF CARRIERS (Q)				
	2	3	4	5	6
2.00	0	-33%	-50%	-60%	-67%
1.50	25%	0	-12%	-20%	-25%
1.33	33%	11%	0	- 6%	-11%
1.25	37%	17%	6%	0	- 4%

CHART 7

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It is enlightening to see that the profit margin is apparently not sensitive to the absolute levels of costs, but is quite sensitive to the ratio of total costs to variable costs. The higher this ratio becomes, the lower the air transportation industry's profits will be. Unfortunately, the trend of this ratio over time has been definitely upward in the air transportation industry as a result of greatly increased capital investments for new aircraft, ground equipment, and facilities. In addition, the annual charges by local airports have risen substantially during recent years. Furthermore, labor contracts are tending in various ways toward greater job security in one form or another, which has the effect of converting variable costs into more fixed, longer-term commitments to the employees. Since the variable cost of flying a jet a certain distance is not substantially greater than that for a piston aircraft over the same distance, the end result of the jet technology has been that higher fixed costs must be allocated over relatively fewer units of production.

Chart 7 shows that, regardless of the size of the market and regardless of the fare level, a three-competitor market can be little better than a break-even operation, and that for healthy profits, only two competitors may be tolerated in any market.

Break-even Operation

Chart 8 shows that the maximum number of carriers in any market is equal to the ratio of total costs to non-variable costs and is independent of market size, length of haul, unit cost, and fare level.

FOR BREAK-EVEN, OPERATING RATIO = 1.0

$$\left(\frac{\text{TOTAL COSTS}}{\text{VARIABLE COSTS}}\right)\left(\frac{Q-1}{Q}\right) = 1.0$$

MAXIMUM NUMBER OF CARRIERS (Q*)

$$Q^* = \left(\frac{\text{TOTAL COSTS}}{\text{TOTAL COSTS} - \text{VARIABLE COSTS}}\right) = \frac{\text{TOTAL COSTS}}{\text{NON-VARIABLE COSTS}}$$

CHART 8

TOTAL COSTS/NON-VARIABLE COSTS	MAXIMUM NUMBER OF CARRIERS
2	2
3	3
4	4
5	5

INDEPENDENT OF MARKET SIZE, LENGTH OF HAUL, UNIT COSTS, AND FARE LEVEL

This rather simple relationship, easy to understand, might also be applicable to other industries and firms which have relatively high fixed costs, such as the fertilizer, plastic, steel, and automotive industries, and possibly even applicable to the number of filling stations at a busy intersection.

Further Extensions

The preceding derivation and results were based on certain simplified assumptions, but what would be the result if the various carriers in a market are not equal and have different drawing powers (or relative load factors), or what if there is a threshold point in the market share versus flight share relationship, or what if an airline's competitors operate more or fewer flights than they really should for maximum profit?

The assumption that all competitors in a market were equal may seem to be a severely limiting assumption, in that there are few markets where all competitors are truly equal. Upon closer inspection of the equations, however, it is clear that we are not bound by this assumption, and that the model can easily be made to apply to unequal competitors. Since industry profits in a market are determined by the number of flights actually scheduled, the value of "Q" can be adjusted to conform to the actual number of trips scheduled in the market. This new "Q" is the number of "equivalent" equal competitors and may be a continuous variable. For example, if three airlines operate in a given market, but one dominates the market, we may be dealing with an effective "Q" of 2.2 rather than 3. By adjusting "Q" in this way, it is possible to use the various equations shown above to describe the actual situation. Furthermore, as shown in Appendix A-3, if the drawing power of one carrier's flights is 10% greater than those of its competitors, the optimum integer number of flights for that carrier and its competitors probably would remain unchanged.

As shown in Appendix A-4, if there were a threshold value in the market share versus flight share relationship (e.g., market share equals 1.10 times flight share minus 5), the optimum number of flights for each carrier would be increased by the slope of the line (10% for the assumed relationship). Unfortunately, the total number of flights, costs, and investment would be increased to the extent that the airline managements assumed this slope to be greater than 1.0.

Appendix A-4 also shows that the optimum number of flights, costs, and investment would be increased directly by the exponent in an assumed (or empirically derived) curvilinear relationship of market share as a function of flight share, for example

$$(\text{Market Share}) = K(\text{Flight Share})^2$$

As shown in Appendix A-5, the optimum number of flights for a carrier to operate is quite insensitive to the actual number of flights operated by its competitors, for the basic diagonal linear relationship of market share = flight share.

RESULTS OF COMPETITION

The customer-oriented competitive nature of the air transportation industry has resulted in a frequency battle with more carriers providing more non-stop flights to more destinations at more times of the day from multiple-airports serving the major metropolitan areas. These new flights may have improved the service and convenience for the traveling public, but at lower load factors and higher costs.

Technological developments have resulted in an equipment battle that has further compounded the economic impact of the competitive frequency battle. The engineers and manufacturers have designed and developed faster, bigger, and more expensive types before the airlines have recouped their capital investments in existing fleets. As soon as one airline buys a new design, competitive pressures force the others to follow, with marked increases in total industry indebtedness. New technology large jet aircraft have been introduced to both replace the smaller first-generation jets and to permit a reduction in seat-mile costs in spite of the inflationary cost pressures. However, this growth in seating capacity has exceeded the normal growth in passengers, also resulting in lower load factors.

Sensitivity Analysis

Chart 9 summarizes the probable impact on flight frequency, costs, capital investment, and passenger load factors as the result of changes in passenger volume, fare level, variable costs per flight, and number of carriers certificated. It can

NUMBER OF INDUSTRY FLIGHTS
(AIRPORT-PAIR TIME MARKET)

PERCENTAGE CHANGE IN CONDITIONS		PROBABLE PERCENTAGE CHANGE IN:	
		FREQUENCY & COSTS	P.L.F.
PASSENGERS	+10	+10	0
	-10	0	-10
FARE	+10	+10	-10
	-10	0	+10
COST PER FLIGHT	+10	0	0
	-10	+10	-10
NUMBER OF CARRIERS CERTIFICATED			
1 → 2		+50 to +100	-43
2 → 3		+33 to +50	-29
3 → 4		+12 to +33	-18
4 → 5		+7 to +25	-14

CHART 9

be seen that under most changes in conditions, the number of flights and costs will tend to be increased and the passenger load factor depressed. Only if the fare elasticity of demand were -1.0 or more might the passenger load factor increase as indicated. Obviously, from a sensitivity standpoint, the number of carriers certificated is most critical in determining the increase in flights, costs, and capital investment, with a resultant depressant of passenger load factor.

Case in Point

This summary has been derived from a rather straightforward analysis, but it might be considered theoretical or abstract. One specific example from actual operations might be mentioned: in 1969, United's service to and from Hawaii produced a pre-tax profit of more than $26 million; the next year, after five additional carriers were granted Hawaiian routes, United's Hawaiian service had a pre-tax loss of more than $17 million; a change on this one route of more than $43 million per year. No carrier is currently earning a reasonable return in the Hawaiian service.

CONCLUSIONS

From the foregoing analysis, we may conclude that:

1. The hypotheses which have influenced the current structure of the industry and level of competition, as stated earlier, have not led to the most efficient allocation of resources for either the traveling public or the air transportation industry.

2. The competitive, economic, regulatory, and technological environment for the air transportation industry has resulted in over-competition with resultant:

    a. Excessive numbers of flights, costs, and capital investments, which must be supported by the fare levels.

    b. Low utilization of productive capacity — low load factors.

    c. Marginal or loss operations.

3. The maximum number of fully-competitive carriers possible in any market can not exceed the ratio of total costs to non-variable costs, and is not a function of the market size, length of haul, unit costs, fare level, or aircraft type. With the inherent increases in fixed costs which have occurred over time, the ratio of total costs to non-variable costs in the air transportation industry appears to range from 2 to 3.

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BASIC DERIVATION for EACH CARRIER

Let M = Industry Passengers
F = Net Fare per Passenger
C = Variable Costs per Flight
P_A = Contribution for Carrier A, similarly for B and C
N_i = Optimum Number of Flights for Each of i Carriers

x = Flights by A
y = Flights by B
z = Flights by C
Q = Number of Carriers
$g = \dfrac{\text{Total Costs}}{\text{Variable Costs}}$

CONDITION A

1. Each carrier schedules for maximum contribution, that is, marginal revenues $\geq$ marginal costs.
2. Market Share = Flight Share.

For $Q = 2$ Competing carriers A and B

$$P_A = \left(\frac{x}{x+y}\right) MF - xC \quad , \quad P_B = \left(\frac{y}{x+y}\right) MF - yC$$

For maximum contribution, $\dfrac{\partial P_A}{\partial x} = 0$ and $\dfrac{\partial P_B}{\partial y} = 0$

$$\frac{\partial P_A}{\partial x} = \left[\frac{(x+y) \cdot 1 - x}{(x+y)^2}\right] MF - C = 0 \quad , \quad \frac{\partial P_B}{\partial y} = \left[\frac{(x+y) \cdot 1 - y}{(x+y)^2}\right] MF - C = 0$$

Solving simultaneous equations,

$$X_{OPT} = Y_{OPT} = N_2 = \frac{MF}{C} \times \frac{1}{4} = \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) \; *$$

For $Q = 3$ Competing carriers A, B, and C

By similar analysis

$$X_{OPT} = Y_{OPT} = Z_{OPT} = N_3 = \frac{MF}{C} \times \frac{2}{9} = \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right)$$

For Q carriers, by extension

$$N_Q = \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) \quad \text{for each carrier} \tag{1}$$

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* In order for the first derivative of P to result in a maximum value for P, the second derivative must, of course, be negative. This will be the case when Q is greater than 1.

BASIC DERIVATIONS
for
TOTAL INDUSTRY

CONDITION A (Continued)

For the total industry,

(2) Total Flights $= QN_Q = \frac{MF}{C}\left(\frac{Q-1}{Q}\right)$

Total Variable Costs $= C \times \frac{MF}{C}\left(\frac{Q-1}{Q}\right) = MF\left(\frac{Q-1}{Q}\right)$

(3) Total Costs $= gMF\left(\frac{Q-1}{Q}\right)$

Operating Ratio $= \frac{\text{Total Costs}}{\text{Total Revenues}}$

(4) $= g\left(\frac{Q-1}{Q}\right)$, independent of M, F, and C

(5) Profit Margin $= 1 - g\left(\frac{Q-1}{Q}\right)$, independent of M, F, and C

For break-even, Operating Ratio = 1.0

$$g\left(\frac{Q-1}{Q}\right) = 1.0$$

Maximum number of carriers Q^* possible

$$Q^* = \frac{g}{g-1}$$

(6) $$= \frac{\text{Total Costs}}{\text{Non-variable Costs}}$$

Again, independent of M, F, and C

FURTHER EXTENSIONS

CONDITION B

1. Each carrier schedules for maximum contribution, and
2. Competitors in market are not equal, such that the drawing power of A's flights = 110% of competitors' flights.

For $Q = 3$ Competing carriers A, B, and C

$$P_A = \left(\frac{1.1x}{1.1x+y+z}\right) MF - xC \quad , \quad P_B = \left(\frac{y}{1.1x+y+z}\right) MF - yC$$

$$\frac{\partial P_A}{\partial x} = \frac{(1.1x+y+z - 1.1x)}{(1.1x+y+z)^2} 1.1MF - C$$

$$\frac{\partial P_B}{\partial y} = \frac{(1.1x+y+z - y)}{(1.1x+y+z)^2} MF - C \quad , \quad \text{similarly for } P_C$$

Solving for maximum contribution, simultaneously,

$$x_{OPT} = \frac{2.4}{(3.2)^2} \frac{MF}{C} = 1.05 \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) = 1.05 \; N_3 \tag{7}$$

$$y_{OPT} = \frac{2.2}{(3.2)^2} \frac{MF}{C} = 0.97 \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) = 0.97 \; N_3$$

$$z_{OPT} = \frac{2.2}{(3.2)^2} \frac{MF}{C} = 0.97 \; N_3$$

That is, a reasonably significant difference in drawing power (or relative load factor) generally will not affect the optimum integer number of flights to be operated.

CONDITION C

1. Each carrier schedules for maximum contribution, and
2. Market Share = 1.10(Flight Share) - 0.05

$$P_A = \left[1.1\left(\frac{x}{x+y+z}\right) - .05\right] MF - xC, \quad \text{similarly for B and C}$$

$$\frac{\partial P_A}{\partial x} = 1.1 \frac{(x+y+z - x)}{(x+y+z)^2} MF - C, \quad \text{similarly for B and C}$$

Solving for maximum contribution, simultaneously

(8) $$X_{OPT} = Y_{OPT} = Z_{OPT} = 1.10\ N_Q, \quad \text{and}$$

$$\text{Total Industry Flights} = 1.10\ QN_Q = 1.10 \frac{MF}{C}\left(\frac{Q-1}{Q}\right)$$

That is, the optimum number of flights for each carrier, and the total number of flights (and costs) for the industry are increased directly by the slope of the regression line of market share against flight share.

CONDITION D

1. Each carrier schedules for maximum contribution, and
2. $\text{Market Share}_A = K\left(\frac{x}{x+y+z}\right)^2$, similarly for B and C

$$= \frac{x^2}{x^2+y^2+z^2}, \quad \text{similarly for B and C}$$

$$P_A = \left(\frac{x^2}{x^2+y^2+z^2}\right) MF - xC, \quad \text{similarly for B and C}$$

$$\frac{\partial P_A}{\partial x} = \frac{(x^2+y^2+z^2)\,2x - x^2 \cdot 2x}{(x^2+y^2+z^2)^2} MF - C, \quad \text{similarly for B and C}$$

Solving for maximum contribution, simultaneously,

(9) $$X_{OPT} = Y_{OPT} = Z_{OPT} = 2\,N_Q, \quad \text{and}$$

$$\text{Total Industry Flights} = 2\,Q\,N_Q = 2 \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right)$$

That is, the optimum number of flights for each carrier, and the total number of flights (and costs) for the industry are increased directly by the exponent in the curvilinear relationship of market share as a function of flight share.

CONDITION E

1. Carrier A schedules for maximum contribution, but
2. Carrier B actually operates K times N_2 flights

$$y = KN_2 = K\frac{MF}{C}\left(\frac{2-1}{2^2}\right) = K\left(\frac{MF}{4C}\right)$$

3. Market Share = Flight Share

$$P_A = \left(\frac{x}{x+KN_2}\right) MF - xC$$

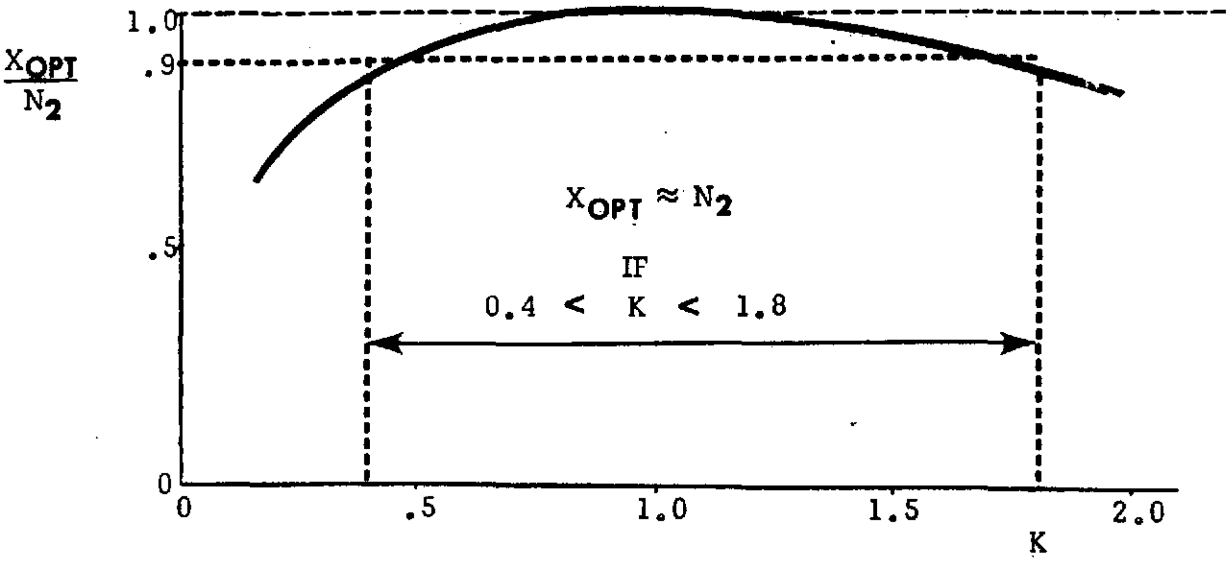
$$\frac{\partial P_A}{\partial x} = \frac{(x+KN_2 - x)}{(x+KN_2)^2} MF - C$$

Solving for maximum contribution,

$$X_{OPT} = \left(KN_2 \frac{MF}{C}\right)^{1/2} - KN_2$$

$$= \left(\frac{K\ MF}{4C} \times \frac{MF}{C}\right)^{1/2} - K\left(\frac{MF}{4C}\right)$$

(10) $$= (2K^{1/2} - K)\ N_2$$



The flatness of this curve means that the optimum number of flights for a carrier is quite insensitive to the actual number of flights operated by its competitor(s), for the simple linear relationship of market share = flight share.