ABSTRACT

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SOME CONSIDERATIONS IN

THE PRICING OF AIR TRANSPORT

DEPARTMENT OF ECONOMICS

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There are some considerations in the pricing of air transportation which merit the attention of applied economic analysis. A review of the development of air fares shows that changes in the underlying cost conditions and the increasing use of market analysis have resulted in the creation of a large number of differential fares. Some of the fares are based on differences in the cost of providing the service while others are the result of discrimination by the firm to cover joint costs.

The nature of the production process in air transport is such that matching supply with demand is not a deterministic process but rather a probabilistic one with pricing problems magnified by the perishability of supply. Under these conditions, estimating the correct supply in different market situations is an important task which can best be carried out by considering the types of demands which passengers with different travel characteristics place upon the system and tailoring the supply to their needs.

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by

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PREFACE

The substance of the originality in this paper is contained in the method developed for the estimation of air transportation supply on the basis of consumer service and operating cost criteria (Chapter IV).

The author would like to acknowledge the assistance of Dr. I. Elce of Air Canada in providing critical comment on the general contents of the thesis and supporting information used in the development of Chapter IV, and of M. J. M. Rousseau of the Université de Montréal for his assistance with some of the mathematical derivations in Chapter III.

INTRODUCTION

The objective of this thesis is to discuss, primarily from the viewpoint of the individual firm, some of the realities of pricing in air transportation with particular reference to the difficulties introduced by the multiplicity of routes served by each airline, the nature of the production process, and the uncertainty of demand for the product. It is an essay in applied economics.

The actual pricing process in the airline industry the world over is closely regulated either by governments or by the airlines themselves acting as a group. Many airlines are wholly or substantially owned by national governments, as is the case with railroads. The government/airline relationship is even closer than in the case of the railways because of the extent of international air operations. The traffic agreements which determine where, when, and how often flights between two countries occur are negotiated by agencies of state on behalf of the airlines involved; and, as a result, foreign operations cannot be considered as purely entrepreneurial actions. The airlines are able to use the power of their national governments to assist them in accomplishing their commercial aims, but they are also subject to this power and, less directly, the power of foreign governments as well.

On their own behalf, international scheduled air carriers as a group have formed an organization called the International Air Transport Association (I.A.T.A.) whose major task is the establishment of a universally acceptable tariff schedule. As a price fixing body, I.A.T.A. has been quite effective, but as might be expected the results have not always been to the benefit of the consumer. If the governments were not such a pervasive influence, the results might have been even worse; as it is, the airlines, some of whom are simply arms of national policy, do not escape public regulatory control even in the meetings of this industry club.

The rate-making procedure in I.A.T.A. is governed by a unanimity rule which requires that all the member airlines agree on all rate proposals. The veto power of the individual firm goes some way toward ensuring that the rate proposals have an economic logic which is acceptable to all the airlines. This requirement also acts as a conservative force limiting the likelihood that any really different or radical fare proposal will be accepted under normal circumstances. There are also political and legal factors which enter into the process and can be expected to influence the final tariff decision. Rather than attempt to estimate the effect of these non-economic influences on the rate agreement, the discussion here will limit itself to the economic considerations underlying the fares.

As a first step in the process of examining airline tariffs, Chapter Two discusses some of the trends in the overall level of airline fares during the past two decades. This period saw the introduction of a large number of new fare types. The first part of the chapter considers the general shift in fares in response to changes in the cost of long haul versus short haul operations. New developments in aircraft technology and passenger handling procedures have altered the basis of the overall fare structure, and the fares recognize the change to some extent. Some individual pricing developments are discussed in the second part of Chapter Two. These developments generally reflect an increasing awareness by the airlines of the variety of cost and demand conditions which accompany the production and sale of air transportation and lead to a large number of differentiated fares as a result.

Chapter Three begins an analysis of the production process in air transportation. Each airline faces a series of markets which are interconnected yet remain distinct with different cost and demand characteristics. Costs vary in relation to a number of factors reflecting various dimensions of the firm's scale of operations, so that each flight may have different costs associated with it. If the costs and demands for each flight were used to determine its price, the product in every market would have a different tariff and the differences would not be explainable simply on the basis of cost variation. Because the firm also tries to maintain some consistancy in the pricing relationship among the diverse products, the price in one market is not set without reference to the prices prevailing in other markets.

There is a relationship between the unit of production and the unit of consumption in air transportation which is typical of other segments of the transportation industry. The firms produce frequencies representing fifty to three hundred and fifty seats which are then sold on an individual basis. This results in a classic condition of joint cost with respect to the individual seats which are fractions of frequencies. There is the additional condition of perishable supply to be considered. Airline pricing practices reflect these influences in somewhat the same way as is the case in the railroads.

To relate production to consumption in this industry involves consideration of the nature of demand for transportation and some study of the interaction of supply with demand as indicated by the behaviour of flight load factors reflecting the variation in demand in the face of a fixed price level and supply schedule. This introduces a question which is very important to the firm - deciding what should be supplied to the market to meet an expected level of uncertain demand. This is a problem which does not arise in any market where perfect knowledge of demand can be assumed and the supply schedule shows no discontinuities.

The purpose of the discussion in Chapter Four is to develop a method which will help the firm to relate expected demand with supply in various types of markets. The suitable supply level is hypothesized to be a function of the number of passengers and their purpose of travel as well as the cost of actually flying the aircraft. By placing a value on the disutility to the passenger at various levels of supply, a model can be developed which shows the output which should be chosen by the firm in order to provide the most suitable level of service to the expected consumers. This optimal level of supply which is independent of price will vary depending not only on the absolute number of passengers but also on the type of passengers expected to use the service. If the consumers are of the type which demands continual seat availability even on short notice and place a high value on not having this availability, the supply level will necessarily be higher in relation to demand than would be the case if the passengers had flexible travel plans and were willing to accommodate themselves to the supply available.

Given the variation in the operating costs on different routes and at different times as well as the variation in the appropriate level of output in relation to uncertain demand, it is not surprising that general rules for airline pricing are difficult to develop. Two guidelines which are not explicitly considered in the existing pricing policies might be suggested on the basis of this analysis. First, prices can reasonably be related to the lead-time provided by the passenger between the date at which the seat is booked and the departure date. This would permit the airline to take advantage of early travel plans to arrange its output in the best possible manner. Second, the price system might recognize the potential improvement in the supply/consumption relationship which can result from using information concerning any flexibility there is in passengers' travel plans as a basis for counter-acting random variations in demand.

II AIRLINE PRICING

Since first becoming an important activity, passenger travel by air has been regulated throughout the world with respect to the rate level and structure. Therefore, airline pricing cannot be discussed purely as an exercise in the economics of competition or even as an example of monopoly or oligopoly. The presence of governments, administrative boards, judiciaries, and "the public interest" precludes such an approach.

But the prices set, however highly conditioned by administrative practices they may be, are still based on analysis of economic conditions. Rather than attempt to present even a clouded picture of the organizational framework within which prices are set, the following discussion is limited to consideration of the economic factors associated with some new fares and fare changes which have occurred in the past thirty years.

The general trend of air fares measured in real terms has been downward, particularly for long distance trips. The shorter length routes have not experienced the same decline in fares however because the costs of handling passengers and aircraft on the ground has increased. This has resulted in an increase in the cost per mile of short flights relative to long flights and, hence, the introduction of "taper" in airline rates. The first section of the chapter outlines this basic relationship in the overall levels of costs and fares.

A number of different types of fares have been introduced in an attempt to reach potential markets for travel and take advantage of special costs conditions. The result is the complex multiple fare situation on many routes. Some of these fare developments are discussed in the second part of the chapter.

A. FARE TAPER

The sophistication in airline pricing has increased considerably since the earliest days when passenger traffic was a by-product of the mail routes and was priced as a joint product. As is so often the case with new products, the sideline became the major activity, and the industry had to face the problem of making the passenger business profitable.

Ever since those times, technology has had considerable influence on the level and structure of fares. Technical advance has a tendency to outstrip administrative reaction, so that today's pricing schemes sometimes do not seem well suited to anything except yesterday's demand and production costs. As an example, we can consider the development up to the early 1950's in air transportation.

The first aircraft used in regular commercial service had a limited range. Even the ubiquitous DC-3, introduced before World War II and extensively used commercially in North America well into the 1950's, had a maximum useful range of less than 800 miles compared with ranges of upwards of 4000 miles for the most modern aircraft.[1] For journeys covering distances greater than the aircraft could manage in a single hop, multiple legs were involved. Hence, average costs per mile did not decrease for longer journeys. One company explained the cost-price relationship as follows:

> It seems safe to assume that back in 1938 when the Company's first commercial operation began, it was expected that with the equipment then available, transcontinental services would be operated as a series of quite short hops. In these circumstances it was perhaps natural that passenger fares were constructed on the basis of a fixed rate per passenger mile, whether the passenger was flying between Montreal and Ottawa - a distance of about 100 miles, or between Montreal and Winnipeg - a distance of somewhat over 1000 miles, with intermediate stops.[2]

There have been other changes as well. Passenger handling and aircraft servicing have become exceptionally complex. Passenger handling costs are terminal-related expenses so they occur only when the passenger begins or, for some costs, ends his journey and their level is "fixed" in relation to the overall cost of transporting each passenger. Included in this type of cost are all the computerized reservations facilities which the airlines

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[1]Peter W. Brooks, The World's Airliners (London: Putnam, 1962), p. 60 and 216.

[2]Letter from Mr. J. E. Nickson, General Sales Director, Trans-Canada Air Lines, November 30, 1960, at the time of the introduction of a new fare structure on T.C.A.'s routes.

maintain, as well as the ticket offices and sales facilities at airports. The costs of providing these services are much the same whether the passenger is going a short or long distance. There are similar costs related to the aircraft handling, such as the ground operations expense of fueling, loading, and cleaning the aircraft. There are a number of aircraft maintenance functions which are related solely to the number of take offs and landings made - brakes and landing gear being two of the most obvious.

Over the years, as the whole air transportation system has become more complex, these terminal expenses have grown, with the result that now the average cost of carrying a passenger has a different relationship to the number of miles flown than it did thirty years ago (see fig. 1).

The airline pricing system however, continued to operate on a constant rate per mile rationale until in 1952, after a rather vigorous struggle, the first "taper" was introduced so that the fare did not increase proportionately with the journey length.[3] Since then, the taper has been increased by changing fares by a constant amount, regardless of distance (see fig. 2).

One reason for the delay in the institution of a taper in fares to reflect the taper in costs was a belief (still present in many airlines) that cross-subsidization was a necessary feature

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[3]John H. Frederick, Commercial Air Transportation (5th edition; Homewood Illinois: R. D. Irwin, 1961), p. 261. See also General Passenger Fare Investigation, Docket 8008 et al., Examiner R. L. Wiser, (Washington: Civil Aeronautics Board, May 27, 1959), p. 164-166.

Figure 1

Cost of Transporting a Passenger - 1938 and 1968

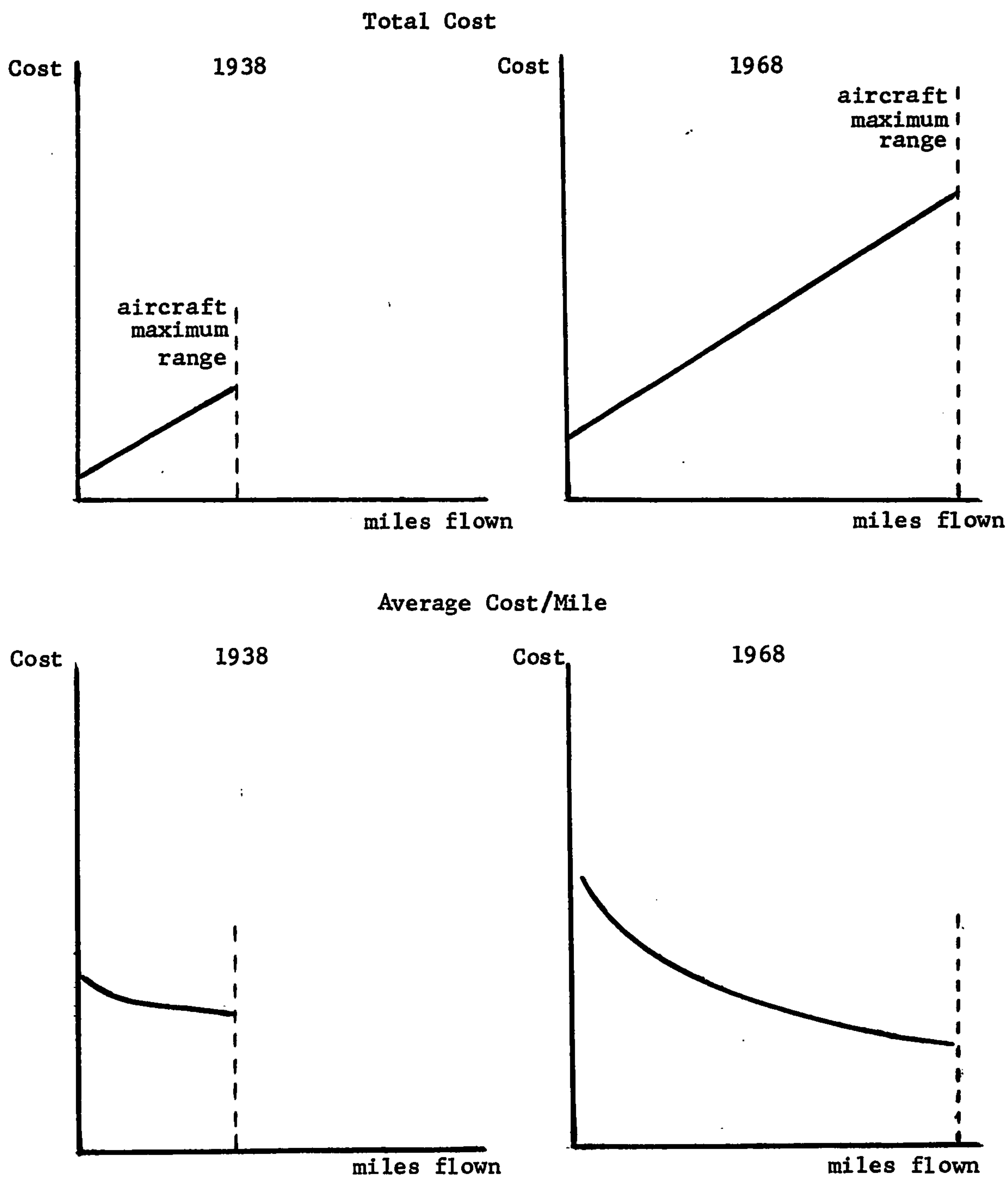
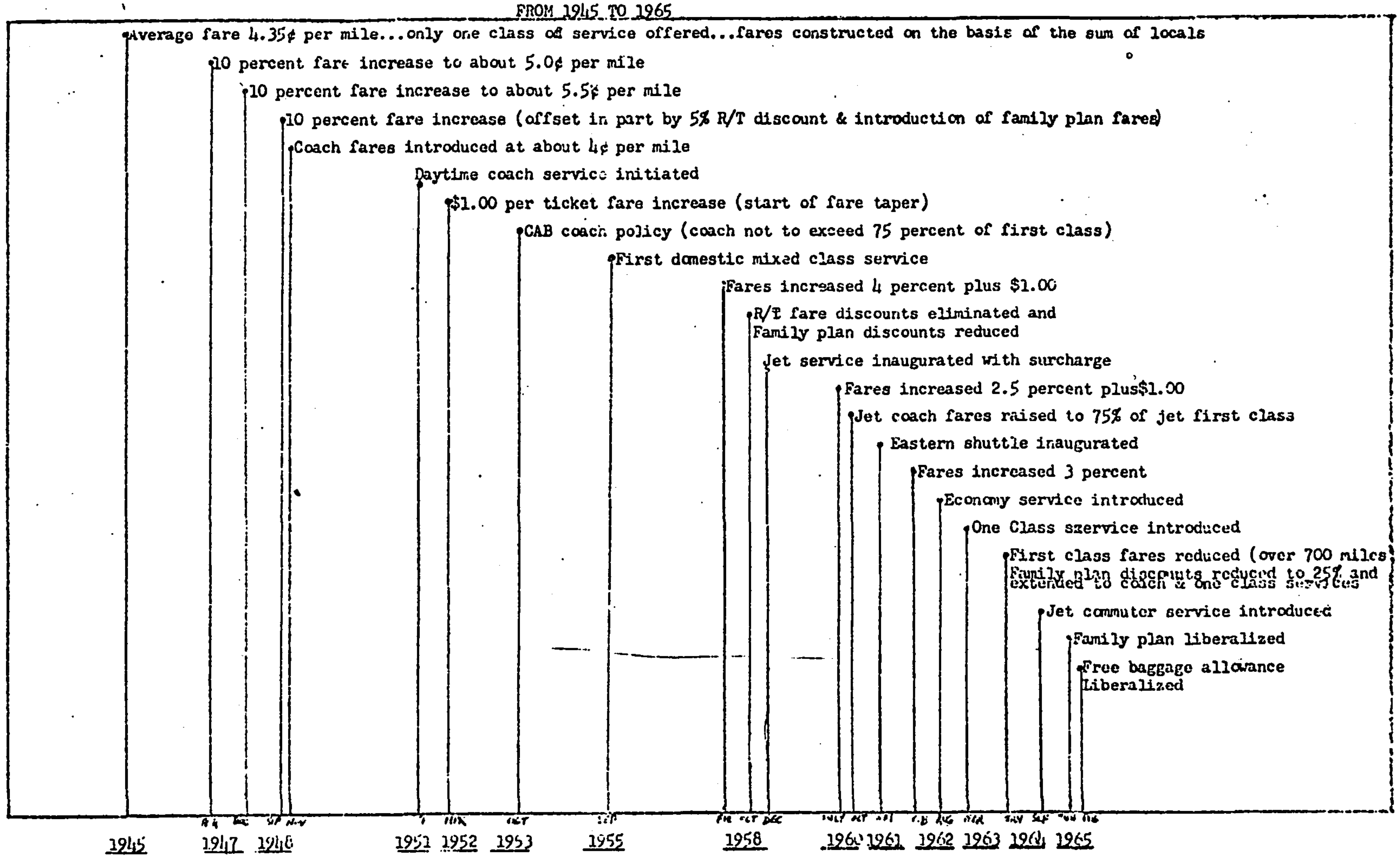


Figure 2

DOMESTIC TRUNK AIRLINES

SIGNIFICANT EVENTS --- AIRLINE FARES
FROM 1945 TO 1965



(Source: Civil Aeronautics Board, Bureau of Economics, Analysis of Domestic Current Fare Structure and Historical Fare Data (Washington: April 21, 1966), Chart 10.

of airline pricing. The airlines looked at all their flying activities as a single unit from a profit point of view. Revenues gained in excess of costs on long-haul routes are used to offset the losses on the short-haul segments. The rationalization of this type of pricing is generally based on social or market development factors. The social obligations which some airlines have (particularly government owned or supported airlines) are very real, and the companies generally recognize that they are losing money operating services on low density and/or short-haul routes at the government's behest. At the present time, cross-subsidization is used to cover the losses on these routes with obvious implications for the fare level on other segments where the market does permit profitable operations.[4] A question arises about whether cross-subsidization is consistent with the objectives of the firm. Should the company maintain a short-haul service which (for one reason or another) is not returning enough to cover the costs of operating it? For overall profitability, the necessary revenue must be acquired elsewhere - most likely on the long-haul routes, where it is generally easier to operate profitably because of the demand conditions (lack of competitive alternatives) as well as lower costs per mile. If the company's desire is to cover the costs of producing each separate product

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[4] See discussion in The Committee of Inquiry into Civil Air Transport, British Air Transport in the Seventies (London: H.M.S.O., 1969), p. 665-669.

from the revenues gained from its sale, cross-subsidization is not a desirable policy. If there is a desire on the part of a regulatory body to maintain fares on some routes at a level which does not provide enough revenue to cover the costs, it would be advantageous to the firm to have any loss covered by a direct subsidy.[5]

The continuation of cross-subsidization exposes the firm to one major danger - the creation of conditions which encourage alternative types of transportation on the routes where the revenue to support the non-profitable operations is being acquired. If there is any chance of competition from new firms which are not practising cross-subsidization, it can be expected that the competition will ultimately come. Unencumbered by unprofitable operations, the new operator can charge a lower price and still be profitable. A regulatory body can, of course, prevent this happening in a tightly controlled industry, but as time goes on and the cross-subsidization continues, pressure to alter the price structure will increase. In the airline environment this has happened twice - once in the late 1940's when the supplemental carriers in the U.S. began operating trans-continental low cost "charters" with such frequency that they became virtually scheduled flights.[6] The Civil

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[5] This point is discussed in S. Wheatcroft, Airline Competition in Canada (Ottawa: Dept. of Transport, 1958) pp. 58-59, 62 and briefly in the General Passenger Fare Investigation, op.cit., p. 166.

[6] Fulda, Competition in the Regulated Industries (Boston: Little Brown and Company, 1961), p. 197.

Aeronautics Board moved to stop the activity in 1949 after considerable pressure from the regular carriers. In fact, reasonable grounds were found for stopping the service on the basis that the planes were overloaded, advertised flights were not completed, and refunds were not granted.[7] The other instance of pressure for price changes is the present expansion of the charter field, particularly on the North Atlantic routes. The existing conditions on charter travel, such as those requiring membership in an organization for a six month period prior to the flight, have been notoriously difficult to apply. The airlines have introduced lower fares for groups, but these have not been completely successful in stopping the shift of passengers from scheduled to charter flights.

Despite this potential for disruption of a fare structure which includes cross subsidized routes, airlines do not appear anxious to stop serving the short-haul and social routes. In the case of purely social routes, airlines would be willing to accept a direct subsidy if a method of payment could be worked out on the basis of an agreed cost-determination method with no government intervention in the day-to-day operations of the service. So far, these practical problems have proved to be insurmountable.[8]

Besides the social routes, there are other short-haul segments

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[7] Ibid.

[8] The railways' experience here with subsidization is relevant, and will likely become more relevant as government and industry work out some of the kinks in the subsidization process and develop a more complete rationale for its application to other modes where it is appropriate.

which do not operate on a profitable basis when they are examined as isolated markets. The presence of allocated costs clouds the issues somewhat, but most airlines are agreed on three things.[9] First, it is desirable that fares by "reasonably" related to the cost of providing the service. Second, few of the short haul routes are covering their costs of operation based on available cost data. Third, fares on the short haul should not be raised to cover the costs of operating the service. Usually, support for the third point is based on a contention such as ". . . very short haul services would not be marketable at a fare that provides for the full recovery of the economic cost of performing the service".[10] The carriers feel that rates which cover costs would not allow them to be competitive in the short haul and would not allow them to penetrate the market at all. The unanswered question is why the services are operated if they are not profitable. Some of the reason lies in tradition — many airlines, if only for public relations reasons, are adverse to the elimination of service on any

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[9] See the replies to a C.A.B. Staff Questionnaire in Civil Aeronautics Board, Bureau of Economics, Rates Division, A Study of Domestic Passenger Air Fare Structure (Washington D.C., January, 1968), Appendix B., especially question four and the replies of the airlines, particularly American, Continental, Delta, Easter, T.W.A. and Frontier. Mohawk, a short-haul operator, is significant exception, having very few routes from which to cross-subsidize.

[10] Ibid, p. 187.

route. Similarly, there is a general feeling that the business generated for the system as a whole offsets the direct loss incurred by the short-haul portion. In both cases, there is no data to either support or refute the airlines' contention, so their decision is really incontestable. Unless the governments or regulatory bodies take positive action to create a system for direct subsidies, the airlines will continue to be willing to cross-subsidize the short-haul routes.

B. PRICING EXPERIMENTS

Airlines charge different passengers different fares. An explanation might be advanced for this on the basis of monopolistic price discrimination. In this regard, much the same controversy surrounds airline costs and pricing as has surrounded railway costs and pricing since the first differential rates were established.

First, an acceptable definition of price discrimination must be arrived at. The most general approach is to reason that price discrimination exists whenever the ratio of price to marginal cost for two products (produced under similar or dissimilar cost conditions) is not equal:[11]

$$\frac{P_1}{MC_1} = \frac{P_2}{MC_2}$$

This definition allows one to compare any two products to

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[11] G. Stigler, The Theory of Price (New York: Macmillan Company, 1966), p. 209.

ascertain which is sold at a more discriminatory price. Other definitions are less general. The most common definition is framed in terms of differing prices for a good which is essentially homogeneous from the producer's point of view.[12] This definition limits the discussion to one of the behaviour of an individual producer or group of producers whose production can be defined on a single cost curve and is therefore applicable to monopolistic price discrimination.

There is, however, an even more restrictive definition of price discrimination:

> Discrimination occurs whenever different units of the same commodity are bought (or sold) at different prices from (or to) different people, or for different uses. Note that if a doctor charges different patients different fees for the same operation, it does not constitute discrimination in the above sense. Operations performed on different patients may be perfect substitutes from the doctor's viewpoint, but they are not as far as the patients are concerned. They do not, therefore, comprise a homogeneous commodity. On the other hand, bottles of the same medicine sold to different patients do comprise a homogeneous commodity. Patients can exchange bottles of medicine. They cannot exchange operations.[13]

Here, perfect homogeneity is required on both sides of the market. As a result, price discrimination in this sense will exist only where the markets are separated so as to preclude

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[12] J. Henderson and R. Quandt, Microeconomic Theory (New York: McGraw-Hill Book Company, 1958), pg. 171; A. Stonier and D. C. Hague, A Text book of Economic Theory, 2nd edition (London: Longman Green and Company, Ltd., 1957), pg. 172; J. Robinson, The Economics of Imperfect Competition (London: Macmillan and Company, Ltd., 1933), pg. 208n.

[13] J. de V. Graaff, Theoretical Welfare Economics, (London: Cambridge University Press, 1957), pg. 150n.

exchange among the consumers. If the separation is inherent in the commodity itself (as is the case with almost all services), then differences in price are not indicative of discrimination.

Using a very narrow definition of price discrimination limits the amount of useful discussion which can be carried on within its framework. As an operational concept (ignoring the theoretical justification) the most useful definition is one of the second type, requiring homogeneity on the supply side but not on the demand side. Within this definition, price discrimination may exist within the rate structure of airlines because of the differing rates which are charged for passengers who make reservations and travel on the same flight in the same compartment of the aircraft. This excludes comparisons between rates on different routes and at different times (which will have significantly different costs) and between passengers making reservations and those not making reservations (where a similar distinction exists). Discrimination exists between passengers primarily on the basis of the length of time which their trip will last - for example, the fourteen to twenty-one day excursion fare which provides a reduction aimed at vacation travellers, trying to take advantage of the expected variation in the elasticity of demand between pleasure and business travel. The discrimination, because it is based on isolating a supposed difference in the demand, will not be exact. Business trips can last for the same duration as pleasure trips, and the airlines do not ask the purpose of the trip when determining the applicable fare. There is some substitutability between the products from the consumer's point of view. The firm thus lacks the ability in practice to determine the final ratio of consumption of excursion/full fare tickets. Time also enters into the process because the output in terms of seats is not pre-allocated to different fare types. If travellers wishing to travel on the excursion fare book first and take all the capacity available, the full fare passengers will be turned away even though the firm could increase its total revenue by cancelling some of the excursion trips already sold.

This is a situation which does not arise with railroad freight rate discrimination because the railroad may add cars to an existing train at relatively low marginal cost. The airline has some flexibility in that it is possible to add a frequency to handle extra demand, but the marginal cost is much higher.

This marginal cost characteristic is the basis of a further point which should be discussed with respect to price discrimination in the airline industry. A very important feature of air transportation is the divergence between the unit of production and the unit of consumption (see below page 61). Our definition of price discrimination assumes homogeneity in supply: this, for the airline, is measured as frequencies whereas consumption is in terms of seats. By implication, we should then test the firm's real price discrimination in terms of variations in the price of total frequencies to separate consumers. There is no discrimination on this basis - a flight can be chartered between any two point at essentially the same price at any time, with any significant variations based purely on costs. The firms do not discriminate when they are selling their output in the same units as it is produced. What appears as discrimination occurs within a different framework - the marketing of partial units of output which are not homogeneous from the airline's viewpoint - the fiftieth seat on a scheduled flight does not have the same cost as the first seat.

The result of these production characteristics and the pricing methods followed by the industry look very much like price discrimination, and it is difficult to say on the basis of the results that discrimination does not exist. But there appear to be alternate explanations for the discrimination which fit the actual developments more closely than a study based on monopolistic price discrimination.

The basic motivation underlying price discrimination in monopolistic conditions is profit maximization. However, there are other motives for price discrimination which appear rational from the producer's viewpoint - specifically, when joint costs exist.[14] It is reasonable to postulate this type of behaviour for transportation firms because they are, first, regulated to a degree which effectively precludes the continued earning of excess profits, yet, second, sufficiently capable of controlling the market to permit them to

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[14] T. C. Bigham, Transportation Principles and Policies (New York: McGraw-Hill Book Company, 1947), pg. 334.

discriminate to some extent.

> If total profits are kept at a reasonable level, charging what the traffic will bear is a sound principle of rate making. But in this case the concept assumes another meaning. Perhaps a new expression is needed. Here the standard for a particular rate is its contribution to the overhead in comparison with the rates on other traffic. This implies a charge far different from the rate that will net the largest possible sum above the out of pocket expenses. When required profit is less than the maximum obtainable, each rate need not necessarily produce all that it can. The rate's revenue needs exceed the added costs only to the extent required in properly apportioning the overhead. Its share may therefore be less than its potential contribution. If the total return is too liberal and if a particular rate can be set at a lower level, still leaving more for the profits than a reduction in the rates of other traffic, the rate in question should be cut. The correct goal is low rates and more business, not high rates and less business.[15]

If this is accepted as a reasonable hypothesis concerning the behaviour of a transportation firm, the rate structure which results will still retain some evidence of price discrimination, although the price and output level will be different than they would be in a monopolistic setting. The joint cost situation which results from the practice of selling individual seats encourages the use of differential rates with respect to cost. If the joint costs were not so significant (as is the case in charter operations), it would appear that differential rates would be unlikely.

The airlines first pricing practice involved a constant rate per mile and single-class service, and the first departure from this formula came in 1952 when people in the airlines began looking

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[15] Ibid., pg. 335.

more closely at their pricing rationale and the effect of price changes on traffic. Most pricing experiments have been based on demand analysis constrained by cost considerations. Some, however, have worked the other way - looking at costs first - and these are more interesting from our point of view.

One of the early experiments in this area was conducted by British European Airways in 1952.[16] Faced with an operational requirement to fly aircraft from London to Glasgow for maintenance, the company decided to experiment with lower fares, primarily because the flights occurred at odd times - usually the middle of the night. They found that ". . . public reaction was remarkable and encouraging"[17]-- a thirty-three percent increase in traffic in five months. B.E.A. began to look further for situations in which the marginal operating cost was low. Long plagued by excessive seasonal peaking problems, the airline recognized the cost implications of equipment acquisition to meet peak demands and has since instituted extensive special fares on specific origin/destination combinations. On the London-Glasgow route where the first experiments were made, there are now in excess of ten fare types offered, with variations for off-peak hour, season, and stand-by traffic.[18]

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[16] The information presented here is largely drawn from Stephen Wheatcroft, The Economics of European Air Transport (Cambridge: Harvard University Press, 1956), p. 119.

[17] British European Airways Corporation, Report and Accounts, 1952-3, (London: Her Majesty's Stationery Office) p. 16.

[18] The fare list includes the following with sample return prices (U.S. dollars) for comparison:

This type of pricing using multiple fares recognizes that transportation sold at different points in time faces different demand and different cost schedules. The policy has not been more widely applied by other airlines (or even by B.E.A.) for two main reasons. The first is the uncertainty which exists about the actual cost and demand on many routes. Large scale detailed market analysis is not a common activity within the airlines (because there are so many markets) and pricing innovations are undertaken where either someone has a good "feel" for the customer using the service, or the route is so unimportant that a faulty pricing strategy will not do serious harm to the company as a whole.[19]

The exception to this of course is the Youth and Senior Citizen Standby plan introduced in 1968 by most North American carriers for service within the continent. The pricing strategy was not specifically based on marginal cost pricing principles, but the characteristics of the marginal cost permitted the airlines to

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a)	first class	$69.60
b)	first class stand-by	55.20
c)	economy class, all year except Nov.1 to Mar.1, Sat & Sun.	46.40
d)	" " , Nov.1 to Mar.1, Sat & Sun.	34.80
e)	" " , Mar.1 to Oct.31, Weekdays, standby	36.00
f)	" " , Nov.1 to Mar.1, Sat & Sun. standby	28.80
g)	" " , Apr.1 to May 31, night	31.60
h)	" " , June 1 to Oct.31, night	35.80
i)	" " , Nov.1 to Mar.31, night	22.80
j)	" " , Apr.1 to May 31, night standby	24.00
k)	" " , June 1 to Oct.31, night standby	28.80
l)	" " , Nov.1 to Mar.1, night standby	19.20

[19]Paul W. Cherington, Airline Price Policy (Cambridge: Harvard University Press, 1958), pp. 149-156.

implement the policy. To cite the Air Canada case, the objective was simply to increase revenues by extending the market to include young and elderly people who might not otherwise travel. A secondary objective was to minimize the risk of a loss, and the easiest way to do this was to minimize the cost increase by keeping the marginal cost down. Therefore, there was a strong case for a standby arrangement which eliminated the need for any additional scheduled service or changes to existing flights. Some small additional costs are incurred for meals, insurance, and passenger handling.

None of the experiments can be called marginal cost pricing. But they do indicate that the airlines have become aware of the value of breaking down their production on the basis of cost, and charging accordingly. Part of the rationale for family fare plans and group fares is the fixed cost of making one booking and handling one "unit" of passengers, whether the size of the unit is one or five or fifteen.

So far, the practical problems involved in the pricing schemes based on concepts of marginal costs have been to avoid the charge that the special rates are "unjustly discriminatory" as has been suggested in case of Youth Stand-by Fares in the United States.[20] To avoid this charge, the rates must be accompanied by conditions which isolate a segment of the market without really appearing to,

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[20] C.A.B. Examiner Arthur Present as quoted in Aviation Daily, Vol. 181 no. 15 (Wednesday, January 22, 1969), p. 106.

so that the fare is technically open to everyone. The extension of standby fares to everyone is not considered "workable" in the U.S., largely because of the deterioration which might result in the existing markets and the general feeling that a good deal of confusion would result.[21] The charge of discrimination leveled against Youth Fares in North America is logical on the grounds that the acceptability criterion for the purchaser is artificial, because difference in age is not a suitable reason for refusing to sell to part of the population. The principle of a different fare for stand-by service is not considered discriminatory, but limitations on its universal availability are.

One experiment which has been attempted is a type of no reservations service usually called "Shuttle Service". This operation is by Eastern Air Lines on various high density short-haul routes in the North East United States. There are no reservations on any flight, but the passenger is guaranteed a seat on the next hourly departure, so that anyone showing up between 8 a.m. and 9 a.m. will leave at 9 a.m., those arriving at the terminal between 9 a.m. and 10 a.m. will leave at 10 a.m., etc. The fare is always the same. It is apparent that with this type of service a major consideration is the availability of aircraft to provide "back-up" capacity for the regular flights. If the passenger is guaranteed a seat, then a seat must be made available. When Eastern introduced the service they felt that they had enough older aircraft around to fulfill this need at minimum cost (i.e. the capital equipment was not a scarce

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[21] See discussion (below p.43) of theoretical aircraft loading which is similar to a "total Standby" concept, and p. 27.

resource) and offer a new service which would gain them an increased share of a competitive market. The implication was that they could handle the peak traffic on older equipment without having to extend their fleet or take aircraft off other routes. To assume the situation was otherwise is to assume they were completely ignoring any consideration of the marginal cost of providing the capacity to service the peak.

Service of this "guaranteed seat" type has not been widely duplicated largely because the other airlines have been aware of the marginal cost involved in their own circumstances - either they do not have enough capacity to guarantee seat availability or the aircraft which could be used are not competitively suitable. When an airline does undertake to run such a service, it must be sure that the presence of excess capacity is not just a short run phenomenon. Once the capital equipment is required elsewhere (or becomes obsolete) the economics underlying the scheme change drastically, and the service will either have to be curtailed or operated with different prices. Airlines generally try to get as much stability in their scheduling as possible, and frequent changes in scheduling practice are avoided to minimize the cost to the company and the confusion to the consumer.[22]

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[22]There is a general feeling that there is a definite cost associated with frequent fare and schedule changes in addition to the cost of the actual physical activities involved in making the change. However, this negative customer reaction cost has never been systematically evaluated and may not, in fact, exist. The cost could be considered to represent the price associated with a lack of the perfect knowledge assumed in theory.

The philosophy behind the "guaranteed seat" approach sometimes helps to defeat the scheme itself. This occurs for the following reason: A company is likely to give most serious consideration to a "guaranteed seat" proposal when it has an excess of aircraft available. The new schedule is introduced, often on a busy, short-haul route, and the passengers arrive at the times of day most suitable to them. One of the problems of the airlines over the years has always been the peaking problem of demand - everyone seems to want to travel at once.[23] By offering the passenger a seat whenever he wants to go, the problem can only be accentuated; and when this happens, more aircraft capacity is required than before. Under these conditions, what appeared to be an excess of capacity in a fixed schedule situation may in fact turn out to be a capacity shortage.

The company can avoid the necessity of maintaining excess capacity and still offer the customer a service which does not require a reservation by operating a fixed schedule on a first come - first serve basis. This is a distinctly different service than the "guaranteed seat" proposal. The main advantage to the company is the potential cost saving connected with the elimination of reservations, and perhaps other services such as baggage checking

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[23]This problem is extensively discussed in airline literature with reference to daily, weekly, and seasonal traffic patterns. See, for example, Wheatcroft, Economics of European Air Transport Chap. IV.

(on a short-haul route, most baggage is carried on board) and expensive passenger amenities. The customer could expect to benefit from the lower price (passed on by the company from its lower costs) and (under some circumstances) the chance to get a seat on short notice. The cost to the potential traveller is the possibility that all the seats will be taken by more eager customers. If none of the potential passengers could make reservations, all those who presented themselves for the flight would have an equal opportunity of getting a seat. Tickets could be issued until either all the passengers were accommodated or the aircraft was full.

There are some rather stringent conditions which would have to exist before this service could be seriously considered to fill a real consumer demand. Such a service would have most appeal for someone who was travelling on short notice and, in addition, was unable to acquire a seat on a reserved basis. It would also have an appeal based on the price differential between the no-reservation service and the regular service. If the difference in price were greater than the expected value of the waiting time (until space became available), the passenger would take the no reservations service.

At the present time, passengers who are unable to obtain a reservation because their request is made after the flight is fully booked can often benefit from the actions of other passengers who make reservations and then do not appear for their chosen flights. As a result, the airline finds empty seats on some of its flights which appeared to be full. An average of about five per cent of reservations are of this type. Passengers who are willing to wait until space becomes available through these "no-shows" as they are called can be moved within a system which is theoretically full. The airlines are, of course, always willing to accommodate those who pay full fare and then wait for a vacant seat.

The pattern of no-shows varies considerably depending on the route, the season, and the person making the reservation. There is a general tendency for business travellers to be no-shows in a larger percentage of cases than pleasure travellers. This is related to the commitment involved in making the plans for the trip. Vacations are generally planned further in advance and reservations are an integral part of the plans. Business trips are more likely to be planned or cancelled at short notice, so the reservations include a larger measure of speculation.

There also seems to be a different attitude toward a reservation in different parts of the country. In the Maritimes, the percentage of no-shows is lower than it is in the rest of Canada. It is hard to define any specific reason to account for this difference, except a wide-spread feeling on the part of Maritimers that reservations are not lightly made nor broken. It is hard to find fault with this attitude.

One of the worst features of no-shows from the airline point of view is their tendency to increase during the busy season on some routes. This arises from the well founded fear among travellers that a single reservation may not be enough when the demand is heavy. If, for some reason, the original reservation cannot be kept, then the possibility of finding another seat at short notice is small. To avoid this, multiple bookings can be made on a number of flights. Then if it becomes necessary to make a change in plans, no inconvenience results (for the passenger, at least). All the inconvenience devolves to the airline which finds that five or six reservations on different flights have all been made by the same person. Often a cross-check of the reservations can be made to pick out these cases and then the customer can be asked directly to chose one of the flights so the other bookings can be made available to others.

The airline pricing system is based on a market (or, more correctly, markets) which does not react as a mass of single minded consumers. In developing the variety of fares which presently exists, the firms have assumed that they are selling a variety of products to a variety of consumers.[24] If all consumers took advantage of any single fare type (like the no-reservations service or inclusive tours), the fare-setting assumptions would be invalid, and the tariffs might be inappropriate. Whenever a new fare is introduced, the major task facing the airlines is to try to estimate the interaction between the new and

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[24] As is the case with most transportation systems. See for example W. J. Baumol, et.al., "The Role of Cost in the Minimum Pricing of Railroad Services" in Denys Munby, ed., Transport (Baltmore: Penguin Books Inc. 1968), p. 124 and P.J.D. Wiles, Price Cost and Output (London: Blackwell, 1956), pp. 142-43.

the old fare structures in terms of traffic diversion and generation and the overall effect on costs and revenues. In this area, the airlines have experienced considerable difficulty.

One recent case where the airlines' estimation of the effect of a new fare has not proved accurate is in the excursion fare market on the North Atlantic. These fares are accompanied by time limitations specifying a minimum stay of fourteen days and a maximum stay of twenty-one days. The fourteen day minimum is designed to keep the fare from being applicable to the normal business traveller who usually makes seven to ten day trips (or less) and is not assumed to be as fare conscious as the vacationer. Similarly, the twenty-one day maximum means that the reduced excursion fare is not applicable for trips which include long stays away from home. Such long stays imply that the cost of the journey is less significant to the traveller than it would be for a stay of shorter duration.

The airlines' forecasts of total revenue with the new fare structure were dependent on accurate estimates of the percentage of the passengers using each fare type and also the total number of travellers. This requires detailed analysis aimed at determining the overall price elasticity of the new fare type as well as its cross-elasticity with respect to all the existing fares. There was a larger percentage of excursion fare passengers than was anticipated by the airlines because they did not have the necessary market information to indicate what they might expect.

Tariff development up to the present time has largely been dictated by technological advances leading to cost reductions. As the cost reductions become general, the airlines undertake (or are pushed into undertaking[25]) fare reductions either in the form of general fare cuts or the introduction of new fares. The new fares are always accompanied by conditions on their applicability to restrain them from diluting the over-all yield too much. It is quite likely that more delicacy (and knowledge) will be required in the future to keep the trend in prices from overtaking the trend in costs; to this point, the cost/revenue relationship has not been clearly defined nor used in the determination of tariff structure and level.[26]

The indefinite relationship between price and costs of production for many transport operations is responsible for the lack of clear connection between the two. Once the airline has made the basic production decision, there are an infinite number of ways that the production can be mixed for the market. Subject to the somewhat flexible constraints imposed by consumer demand for the products, the firm can choose the product mix which it will sell without significantly changing overall cost.

If this problem were considered in a theoretical fashion, it might be formulated as a non-linear programming model, with

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[25]For an example, see Richard E. Caves, Air Transport and Its Regulators, (Cambridge: Harvard University Press, 1962), p. 370.

[26]Paul Cherington, *Op. cit.*, p. 457.

non-linear probabilistic constraints relating the demand for each fare-type to the cross elasticities of demand in relation to the other fares. If this model were run for various levels of price for each type of fare, a profit maximizing structure (or group of structures) could be determined. A tremendous amount of market analysis would be involved in such an approach, and it is doubtful if such information could be obtained or maintained for a useful period of time.

The problems of airline pricing are just beginning to become evident. Until now, the industry has been able to offer its customers what were generally lower prices particularly in real terms accompanied by a product of increasing comfort, speed, and safety. The job of the price-setter has been simplified by the force of technological changes and rapid market penetration, but these conditions are not likely to remain present much longer. What were, in the past, isolated instances of marketing knowledge leading to successful fare policies in difficult areas will have to become more widespread phenomenon, or the airlines will find themselves saddled with undesirable revenue levels from unwanted markets.

III THE PRODUCTION OF AIRLINE TRANSPORTATION

A. PRODUCTION COSTS

1. Static Conditions

A common problem which arises in most transportation industries is defining the commodity which is produced. In the majority of cases, the firm is offering transportation services between a number of cities at a number of different times. A very rigid definition of the commodity produced by an airline would suggest that each flight, unless it operates at the same time and on the same route as some other flight, is a distinct service which serves a separate market. This implies that cost analysis of the output would have to be very detailed to relate costs to a single product. From the firm's point of view, the information required to do this is available only at prohibitively high cost, if at all, and such an approach would be of little value in determining overall cost levels. For useful discussion, the definition of what constitutes a separate good must be relaxed. The question then is, how far to go in grouping commodities so that the unimportant factors in cost determination are eliminated.

The most general measure of output, combining all production in one figure, is available ton miles. This figure represents the total activity of the firm, ignoring the different characteristics of the routes flown, the aircraft used, and the passengers carried. It is, of necessity, a conglomeration of products, not a single product, so there is no *a priori* reason why one should expect a firm's operating costs to be determined simply by the output of total available ton miles. The cost of operating any route (or flight) involve fixed and variable costs which can be expected to lead to differences in overall cost levels. Compare, for instance, two airlines, both of which have a total output of two hundred million available ton miles, with differing route systems - one dominated by highly seasonal long-haul vacation travel, and one carrying short-haul business travel on a heavily-used routes. Because of the differing nature of the product in the two instances, the cost situation might be very different as well. But most airlines produce a conglomeration of products on a lot of different types of routes, making the aggregate output more similar, so that differences in cost levels resulting from structural variation are not apparent when the total ton miles produced are used as a measure. There is a very high correlation between total cost and available ton miles produced by United States scheduled domestic carriers of all types and sizes (R = 0.988)[1], and the average cost curve estimated on this

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[1]The equation is

$$C = 8.977 + 0.2105\,X$$

where C = total operating expense (in millions of dollars)
X = available ton miles produced (in millions)
Standard Error of Estimate = 36.544

The equation for figure 3 is then

$$\frac{C}{X} = 0.2105 + \frac{8.977}{X}$$

basis is a classic example of an L-shaped cost curve, with very little in the way of economies or diseconomies of scale once output surpasses four hundred thousand available ton miles per annum (see fig. 3). These economies of scale seem to occur at a low level on the cost curve. In spite of this, there are only twenty-five airlines in the world at the present time whose output exceeds this level, and their revenues for a single year will all be in excess of seventy million dollars. For carriers based outside North America or Western Europe, this level of production is just not attainable, even when they are national airlines with a guaranteed monopoly or a single competitor on all routes to and from their home country. Although they cannot achieve the necessary total output for minimum average costs, these smaller international carriers are able to continue operations protected by the barriers to entry and supporting action of I.A.T.A. and their own governments' power to regulate fares and services in bilateral negotiations.

For the individual firm, such a relationship is just a general indicator of overall average costs. They are much more concerned with the specific components making up the total production. If anything can be surmised from the total relationship, it is the necessity of attaining an overall output of four hundred million ton miles to achieve the majority of the economies of scale which are available. On the basis of the data presented here, there appears to be a case for increasing the size of the smaller carriers until they reach this minimum size. Of course, if this happened,

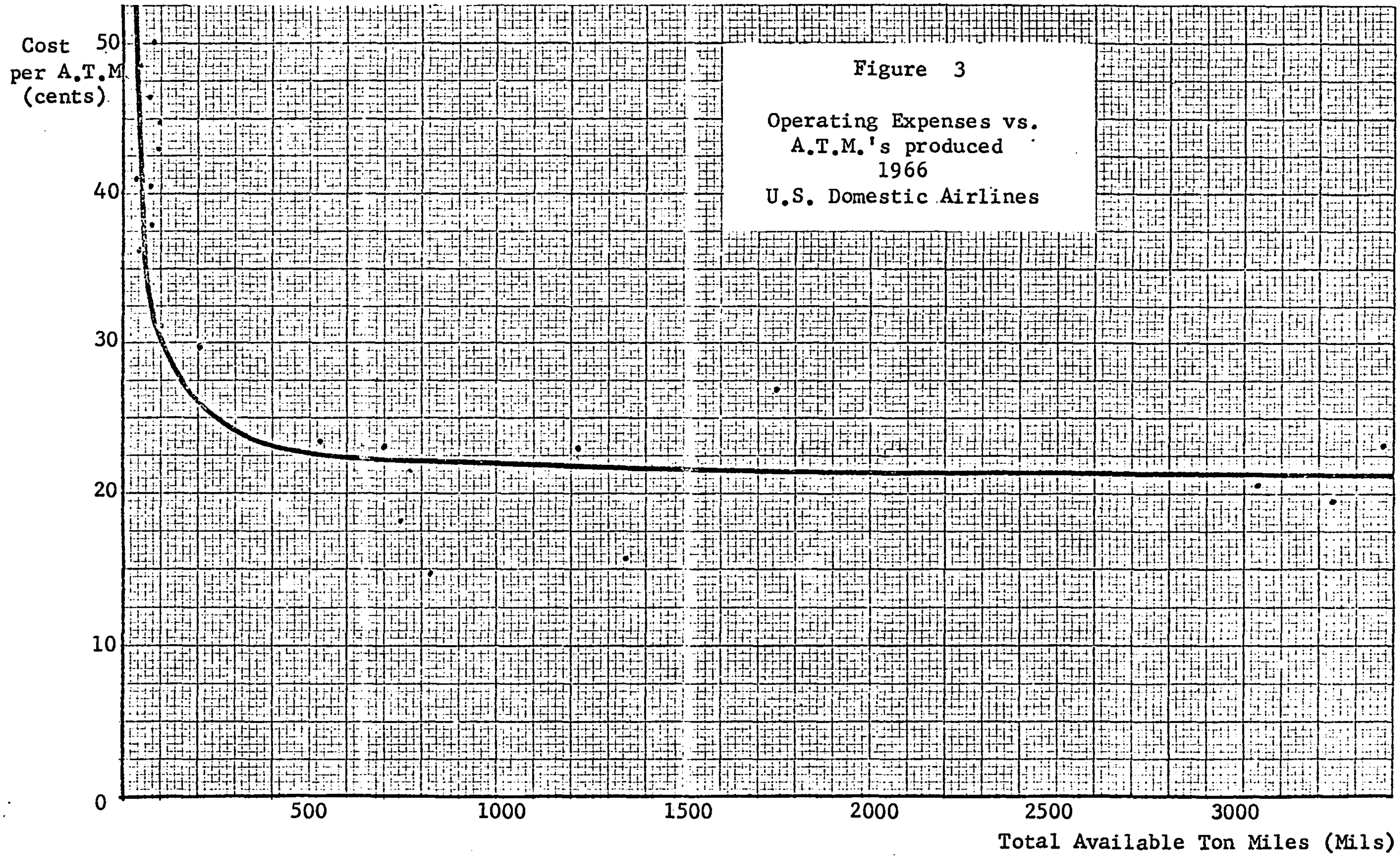

Figure 3

Operating Expenses vs.
A.T.M.'s produced
1966
U.S. Domestic Airlines

Source: Civil Aeronautics Board: Handbook of Airline Statistics - 1967 Edition (Washington: C.A.B., 1967) pp. 7,10 it might soon be discovered that size was not the key to cost reduction, and there were other, more important factors, such as route structure and traffic density, which determined costs. It is possible that such relationships can be hidden in the correlation between total output and cost, and that simply altering the output of the firm without adapting route structure will not produce lower costs.[2]

Individual firms in the airline industry are interested in obtaining more detailed information about costs than is provided by the simple relationship between total output and expenditure. One of the key factors is the average stage length operated by their aircraft fleet. Although the type of aircraft used is often an important factor, even averages by airline are significant. The graph which results (figure 4) shows a declining average cost as stage length increases. The taper is largely explained in terms of passenger and aircraft ground costs, taxi and climb fuel costs, air traffic and landing fees, maintenance costs on brakes, thrust reversers and wheels, and other cost items which only occur when the aircraft lands or takes off. The chart shown here is based on average costs and average stage lengths for United States domestic

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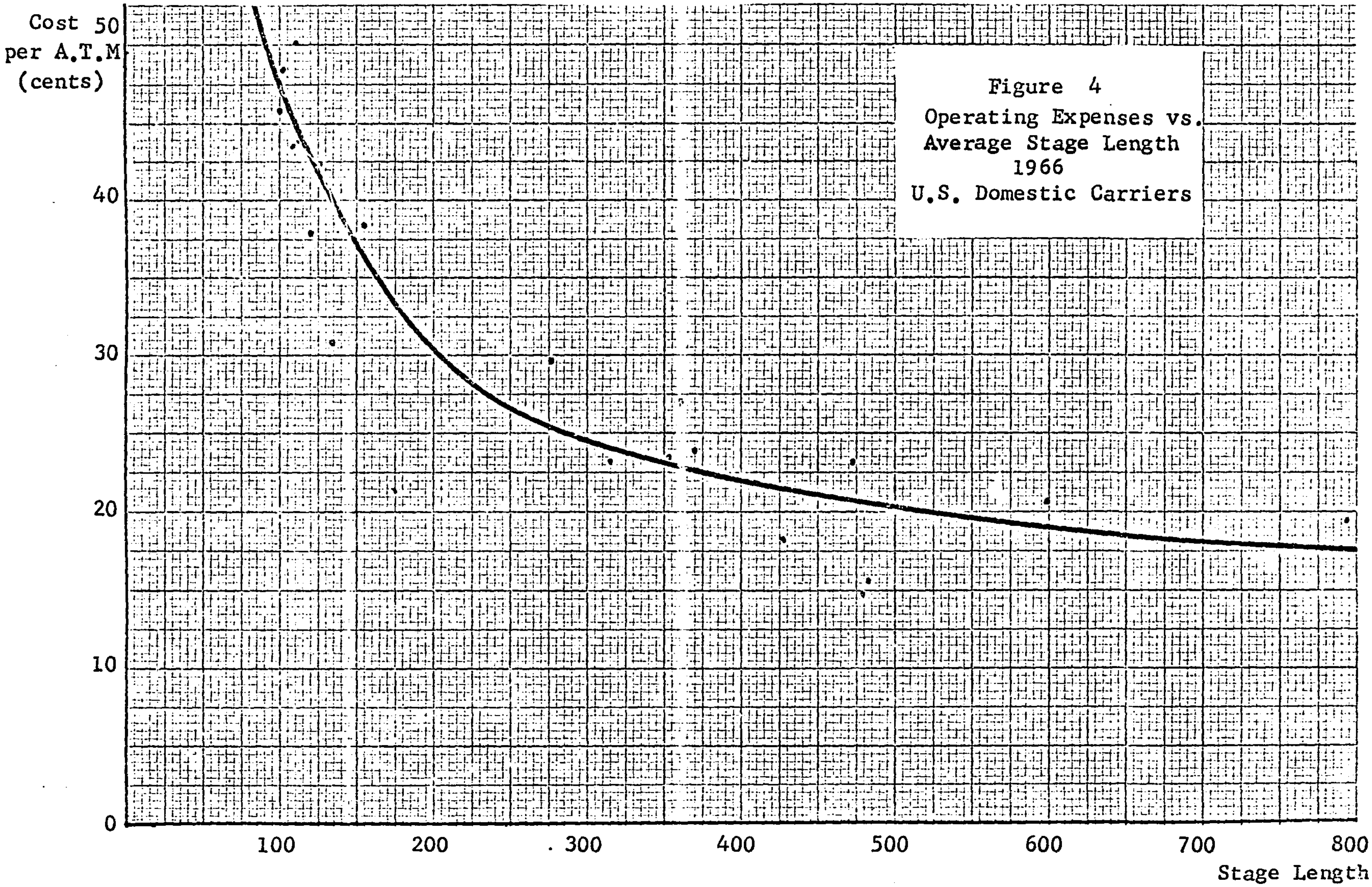
[2] The level of output at which economies of scale become apparent has increased as the size and speed of the most efficient aircraft type has increased. For a comparison, see S. Wheatcroft, The Economics of European Air Transport (Cambridge: Harvard University Press, 1956), p. 79, which shows that the minimum size for efficient operations in 1952 was about 125 million ton miles.



Source: Civil Aeronautics Board: Handbook of Airline Statistics - 1967 Edition (Washington: C.A.B., 1967) pp. 8, 10.

carriers, but even such aggregate measures as these show the relationship between costs and lengths of haul quite clearly. The equation for this curve is[3]

$$A = 13.338 + \underset{(302.)}{3422/S}$$

with $R^2 = 0.963$
where A = cost per available ton mile
S = average stage length
t value = 16.843
standard error of estimate = 3.456.

It is worth repeating that this equation does not show the relationship between cost and output, but rather the relationship among the average costs of production of different commodities. Because the average stage length is an important factor in explaining the behaviour of costs, an equation such as this illustrates the structure of the cost of producing different products, and is

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[3] Because of the gap in average stage lengths between 150 and 275 miles, a case can be made for treating the two groups of carriers Local Service and Trunk, separately. If this is done the two regression equations obtained are:

a) for Local Service airlines

$$A = 74.35 - \underset{(0.059)}{0.266S}$$

$R^2 = .805$
Standard error of estimate = 3.846

b) for trunk carriers

$$A = 29.3 - \underset{(0.009)}{0.017S}$$

$R^2 = .54$
standard error of estimate = 4.069

The two lines closely approximate the composite curve from zero to 150 miles and from 300 to 800 miles. They intersect at 180 miles. The fit of the composite curve is slightly better statistically, however.

therefore often used by the individual airlines to study the cost relationships among different routes which they operate.

There is another important cost determinant besides stage length and total output which should be mentioned. The average cost per flight or per passenger for station operations varies as the density of operations at the station increases.[4] This factor adds to the difficulties involved in making a direct comparison of the cost levels on two different routes, even if they have the same stage length and,as a result, might be expected to entail the same cost per flight. Recent experience at large stations suggests that the relationship between station size and costs is U-shaped rather than L-shaped. Kennedy Airport in New York has become so large and busy that higher costs are incurred in operations to and from it than between smaller stations. The queues of aircraft for take-off and landing result in the consumption of additional fuel and the lengthening of flights. In addition, the amount of time spent by airport staff in moving around a large station can have an adverse effect on ground handling costs. For reasons such as these, flights operating between two medium density stations will experience different costs than similar flights between high density points.[5]

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[4] S. Wheatcroft, Op.cit., p. 90.

[5] The situation in this respect is much the same as with railways. See J. M. Clark, Studies in the Economics of Overhead Costs (Chicago: University of Chicago Press, 1923), p. 282.

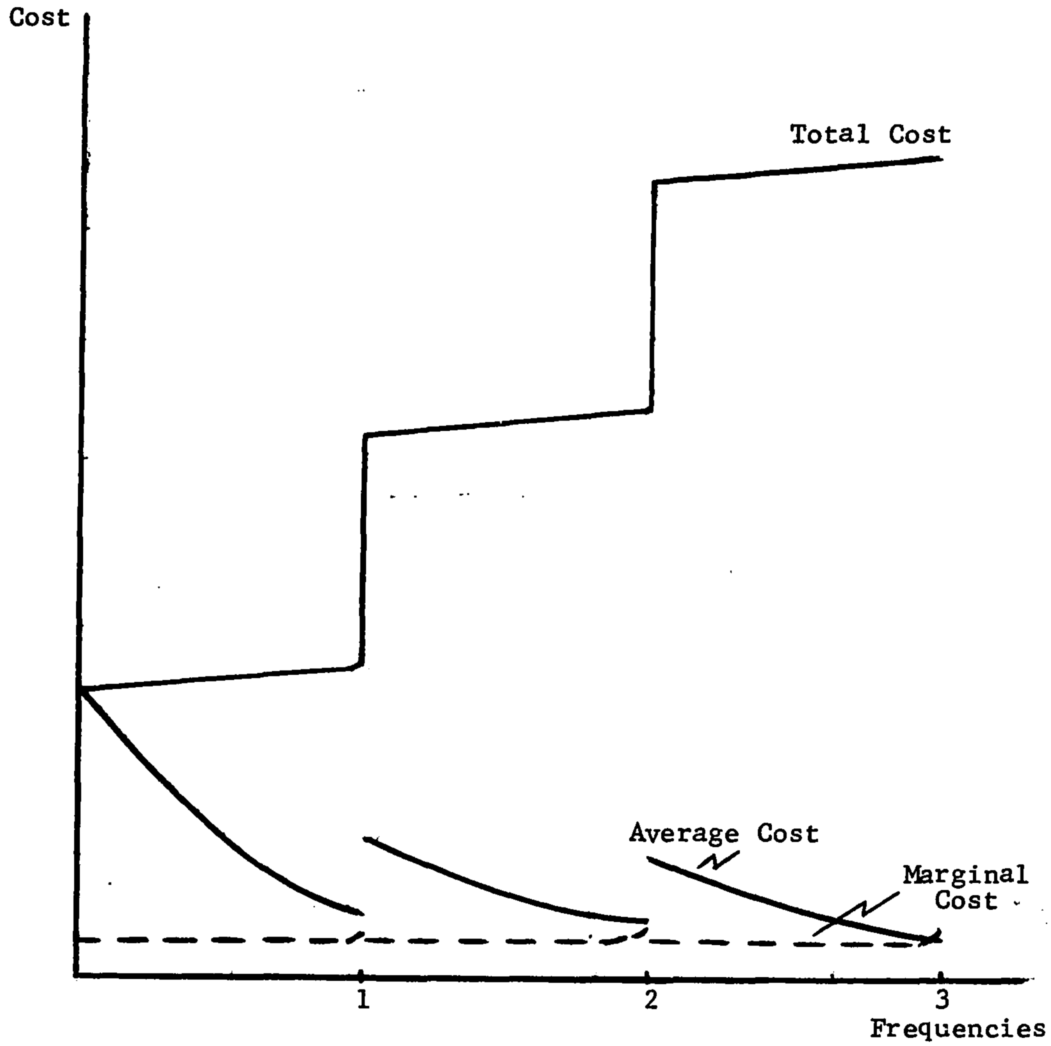
Station operations are also the source of some of the joint costs associated with airline operations. Most airports handle flights serving both long haul and short haul routes. Often the same crews, the same gate facilities and the same passenger handling personnel are used for many types of flights, with the result that an accurate allocation of costs to any individual route or flight is virtually impossible from a practical point of view.

All three of these factors affect the level of total costs for an airline. There are differences in cost associated with the total size of the firm as a result of economies in fleet utilization, maintenance, and administrative costs. There are additional cost differences associated with variations in stage lengths operated; and there is also a significant impact on costs from the intensity of operations experienced at the various stations in the network. It is difficult to include all these diverse factors in a single cost function. To get a reasonable relationship between cost and some measure of output, the discussion will be limited at first to a single route operating between stations whose costs are assumed to be invariant with respect to the number of operations.

Within a more traditional framework from an economic point of view, it is possible to construct a graph which relates cost of operation to units of output, with the units as aircraft frequencies. Under static conditions, this graph (figure 5) will represent the total cost of production is a distinctly stepped curve, with discontinuous marginal costs and average costs.

Figure 5

Cost of Production
Static Conditions



This is a reasonable result of the "lumpiness" of the units involved. Each frequency can be broken down into a series of seats. If no passengers were carried, the total cost function would simply be a series of discontinuous horizontal lines, with no increase in cost until an entire new frequency is added. When passengers are added to fill the seats, a positive marginal cost will exist, representing the cost of processing the ticket, insuring the passenger, serving food, etc. This marginal cost is very low (relative to total cost) and is constant until the aircraft approaches one hundred percent of capacity. As this level is reached, some increase in the cost of handling each additional passenger can be expected due to the number of people involved. When the aircraft is completely full (aircraft, unlike railway cars or buses, have a capacity limited by the number of seats, with no flexibility provided by permitting standees), another frequency must be added and total cost jumps, after which marginal cost returns to its low level. Average cost per passenger increases, but not to the previous maximum level.

Price determination based on this kind of concept of cost behaviour is, to say the least, difficult. Strict marginal cost pricing would offer the initial customer an extremely high charge designed to cover all the expense necessary to get the flight off the ground. Later customers who could get on the same flight would pay very little. This pattern would be repeated for each flight.

As each flight became more crowded, the consumer who had paid the high initial cost would find there was a change in the nature of the product which he was consuming. After paying a fare large enough to cover all but a small portion of the total cost, this individual would still obtain only one seat and be surrounded by consumers who had paid much less. In some sense, it can be said that this is legitimate because he obviously felt more in need of the product than the other people. However, if this pricing system were "institutionalised" in some way, changes would take place. At one extreme, the rich, highly motivated consumer could buy an entire frequency for himself by paying enough to cover the extra revenue which all the rest of the passengers would normally contribute. The rest of the consumers would then be left -- unable to take advantage of the lower marginal costs for the remaining places and unable or unwilling to pay the high cost of their own flights. On the other hand, groups of passengers would begin to circumvent the pricing system by grouping themselves into larger units and acting together to purchase entire frequencies. It is not hard to recognize this situation as something very closely akin to existing charter flight arrangements.

The use of marginal costs as a basis for pricing in those circumstances does not seem to be practical. This is attributable to a number of factors. First, the product which the airline produces is not the product which the traveller consumes unless each traveller has his own frequency or a group of passengers act as a unit and charter a frequency. If the airline sells individual seats on scheduled flights, it is selling its production in small pieces, so the marginal production costs are not applicable.

If the company wished to approximate marginal cost pricing conditions, it would have to sell only charters or entire frequencies to (for example) travel agents who could then resell the pieces. This would push the problem of determining the price to the consumer one step surther away, perhaps allowing more flexibility in pricing.

The marginal cost pricing problems are rooted in the indivisibility of the product and the resulting discontinuties. This makes marginal cost pricing not only administratively difficult but also theoretically unjustified from a welfare point of view.[6]

2. Production over time

If airline demand and production conditions resembled those described above, the price actually arrived at might be something similar to an average cost-based price. Given that all the aircraft flew one hundred percent full, the firm could establish a fare large enough to cover all costs including a normal profit. If demand were known, cost determination would be simplified and peak-season traffic could be charged a suitable amount to meet the cost of the extra capacity required. In fact, if the demand function were known, a given capacity (qo) could be fully utilized throughout the year by judiciously applying suitable rates at the appropriate time (figure 6). As the demand curve shifted with changes in season, the tariffs could move to the required level.

Such a pricing/output scheme does not provide any information on the profitability of the operation. Assuming cost conditions are constant over time, the system would not provide maximum profits except under very special circumstances when the various marginal revenue curves all intersected the marginal cost curve at exactly the point of capacity (figure 7). It would be entirely fortuitous if this were indeed the case.

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[6] J. de V. Graaff, Theoretical Welfare Economics (London: Cambridge University Press, 1967), p. 144-5.

Figure 6

Flexible Pricing for Maximum Utilization

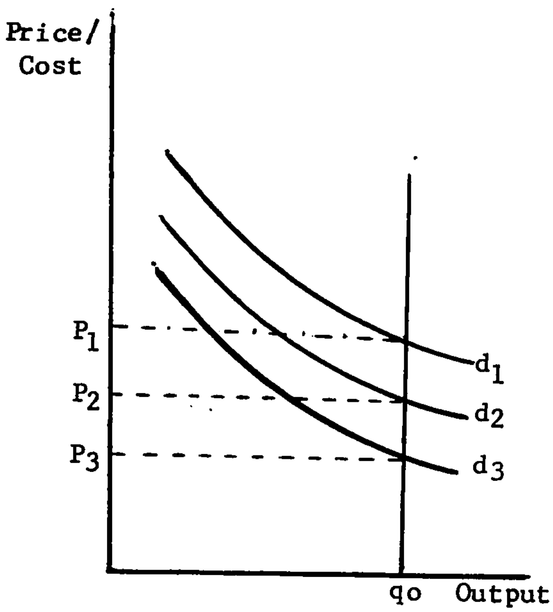
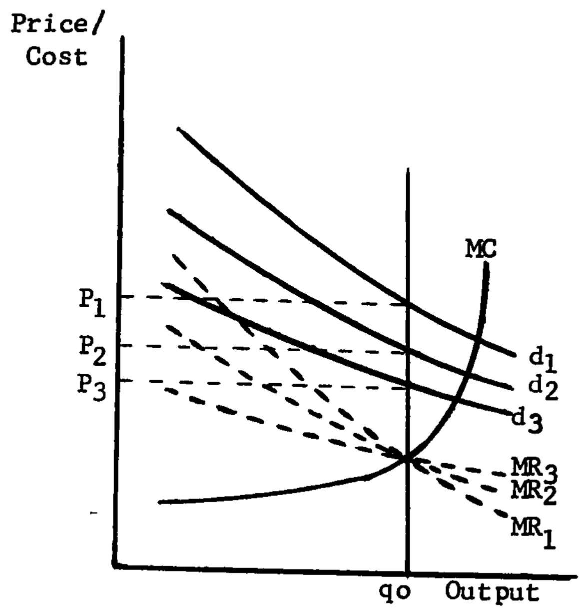


Figure 7

Profit Maximizing Flexible Pricing with Maximum Utilization



In the absence ofthese special conditions, a profit maximizing policy would result in changes in both price and capacity. Renting aircraft is a viable method of increasing capacity in the short term, and output restriction in periods of lighter demand is certainly feasible.

The two hypothetical cases outlined above are based on a good (or rather goods) produced over a single route or origin/destination pair. The normal airline has in hand a large number of routes and each will have a number of different demand functions. Hence, it becomes possible to consider altering the production level of any single type of goods over time without changing the overall cost to any large extent. This can lead to a greater flexibility and a potential for increased profit for the airline. The desire for such an arrangement by the airline is shown in their eagerness to obtain what is known as a "balanced" route structure, with off-setting seasonal routes (Europe and the Caribbean or Transcontinental and Florida) so that there is always a peak to be served. Thus the peaks become less significant from a capital cost point of view. As the capacity costs become more stable, the firm may regard the traffic peaks on individual routes simply as part of a stable over-all demand level as well, thus providing an opportunity for the firm to offer rates at the peak season which would be less than it might otherwise charge. Because the peak on an individual group of routes is not a peak as far as the entire operation of the firm is concerned, special capacity may not be required.

This situation shows again some of the possible anomalies which exist between supply and demand in the transportation industries. The capital equipment is extremely flexible in its ability to switch from production of one product to another simply by re-routing it. With such adaptability, the firm would appear to have a considerable number of alternatives available to it as far as allocation of production is concerned.

If, through judicious allocation of aircraft to the routes in the system, an airline were able to stabilize its overall utilization rate at the maximum potential level (of all factors, not just aircraft), the need for peak and off-peak rates on a single route based on cost variation would disappear. This would seem to offer an opportunity for the firm to provide service to the public at a price consistent with the cost of producing it. If the firm can be assumed to be further aided in its attempts through perfect knowledge of demand in each of its markets, then by setting the price at a level sufficient to cover all costs (including profit) the firm could ensure that none of its production was cross-subsidized from more profitable routes nor, on the other hand, was used to extract above average profits from some consumers.

These conditions might seem somewhat idealistic. Certainly they are never found in real circumstances. But does their presence guarantee the attainment of the specified objective? A simple model can provide some indication. Assume:

a) A cost function for each route i of the form

$$c_i = A_i + B_i x_i \qquad (3\text{-}1)$$

where c_i = total cost of production for route i

x_i = number of frequencies on route i

The cost on each route is independent of the production level on all the other routes. This is consistent with a condition where the firm's resources are fully allocated over time, so there is no peaking or excess capacity present at any point in time.

b) Total production is fixed (with a single aircraft type in the fleet)

$$\sum_i a_i x_i = X \qquad (3\text{-}2)$$

where a_i = time required to operate a frequency on route i

X = total amount of time available for flying

c) Revenue is based on the level of costs[7]

$$P_i = M \frac{c_i}{x_i} \quad \text{for all } i$$

so that $R = \sum_i P_i x_i = M \sum_i c_i$ (3-3)

where P_i = Revenue from one frequency on route i

M = Revenue/cost ratio or markup rate

R = total revenue

d) Demand is known at each price

$$P_i = f_i(x_i) \text{ for all } i$$

For purposes of discussion, assume a demand function for each of the form[8]

$$P_i = \gamma_i x_i^{-e_i} \quad (3\text{-}4)$$

where $-e_i$ = output elasticity on route i

This model can be used to show some of the characteristics of a non-profit maximizing firm which uses a markup objective of

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[7] This assumption is not consistent with profit maximizing behaviour, but it is nevertheless fairly common in regulated industries. The Civil Aeronautics Board in the United States maintains a "guideline" rate of return on investment for domestic U.S. airlines, and a rate of return on turnover has been suggested as appropriate in the U.K. See K.M. Gwilliam, "Domestic Air Transport Fares" Journal of Transport Economics and Policy (II), pp. 206-207.

[8] This function is similar in form to $x = bp^{-a} + c$ which is given as an example in R.G.D. Allen, Mathematical Analysis for Economists (London: Macmillan and Co., 1961), p. 112. The difference is the presence of the "c" term which provides a finite demand level at zero price in Allen's example. The simplified form used here is easier to handle mathematically and retains all the other essential properties.

(M - 1) percent in excess of costs to set fares on all routes. Because the markup, M, is the same on all routes, it will have to be greater than one for the firm to survive. This can be contrasted with a policy of cross-subsidisation which would imply that M is less than one on some routes, with the costs being covered from other routes where M is greater than one. The firm is non-profit maximizing because marginal cost is not equated with marginal revenue to determine price and output levels. Nor does the organization take advantage of the opportunities for price discrimination or "value-of-service" rate making which occur so often in transport. In order to obviate the need for consideration of a rival's reaction to price and output policy, it is assumed that the firm is a monopoly.

This model represents an airline which, with perfect knowledge of demand, is attempting to eliminate any peak in total demand through judicious pricing and output allocation, charging the same fare in relation to cost on all routes. We are interested primarily in finding the answers to two questions: first, is such a policy feasible, and second, if it is, what conditions does it imply in the individual markets.

Expressing the markup rate, M, in terms of production, x_i and price, P_i, for each route we get:

$$M = \frac{\gamma_i x_i^{1-e_i}}{A_i + B_i x_i} \qquad (3\text{-}5)$$

and

$$M = \frac{\gamma_i^{1/e_i} P_i}{A_i P_i^{1/e_i} + B_i \gamma_i^{1/e_i}} \qquad (3\text{-}6)$$

Three cases must be considered, depending on the elasticity of demand. In each case, we are interested in the behaviour of M for changes in x_i, the level of output on route i. We can ignore the effect of changes in the price level on M because output and price are directly connected through the cost function which, under our behavioural assumptions, is also the pricing basis. This means that there is a consistent relationship between price, output, and markup rate. That is, the maximum markup rate with respect to the price level will be the same as the maximum markup rate with respect to output, and the price/output combination at this maximum will be consistent with the demand function specified in equation 3-4.

a) $e_i < 1$

This case provides a single maximum value for the rate of return at $x_{i0} = \dfrac{A_i\ (1 - e_i)}{B_i\ e_i}$ (see figure 8).

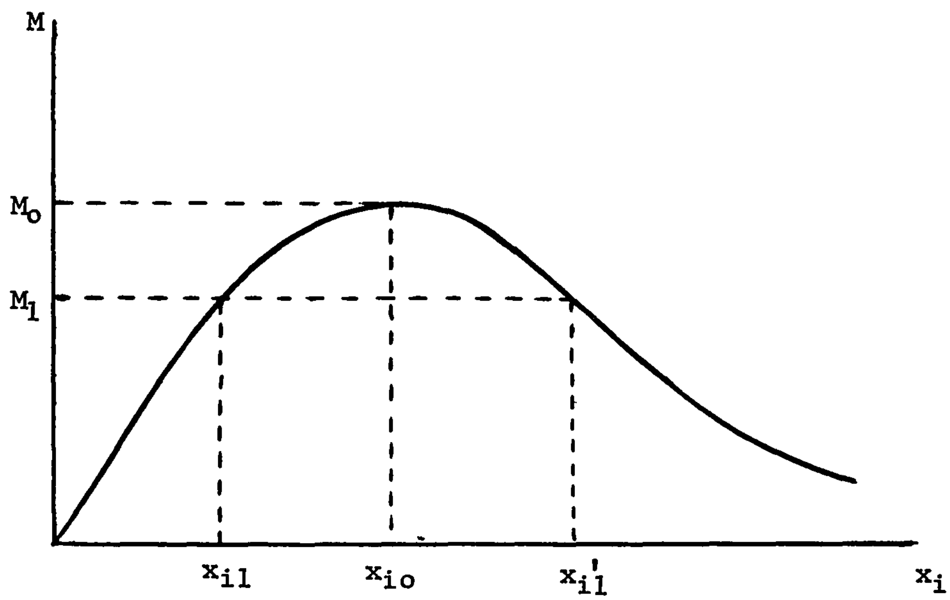
If M is set lower than this maximum value (e.g. M_1) two possible values of x_i (x_{i1} and x'_{i1}) can be chosen consistent with it, so the solution is not unique. The value of x_i at which the maximum value of M is attained is determined simply by the cost and elasticity figures. For a given e_i, the optimum output level is determined by the ratio of fixed costs A_i to marginal costs B_i. If there are no fixed costs, the maximum value of M will occur where x_i is zero.

With inelastic demand and a linear cost function, the total revenue/total cost relationship will be of the form shown in figure 9,

Figure 8

Markup vs. Output

$e_i < 1$



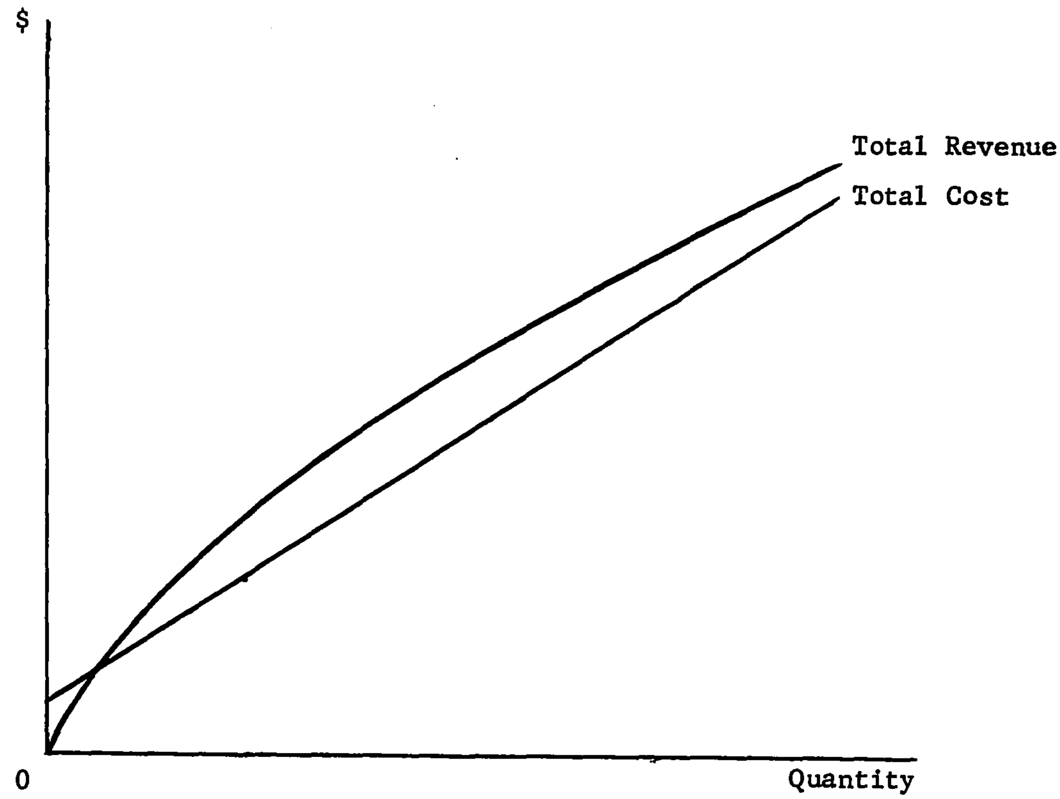
with $M_o = \dfrac{\gamma_i \; x_{io}^{\,1-e_i}}{A_i \,/\, e_i}$

with total revenue increasing as production goes up. Of course, the slope of the total revenue function is dependent on the elasticity of demand, which means that the output level for maximum achievable markup is a function of the elasticity. As the elasticity approaches zero, the "hump" in the markup vs. output relationship (figure 8) will occur at higher and higher levels of output, until $e_i = 0$, when the "hump" disappears and the total revenue function becomes linear. Under these conditions the maximum

Figure 9

Total Cost and Total Revenue

$e_i < 1$



value of M will occur when output is infinite.

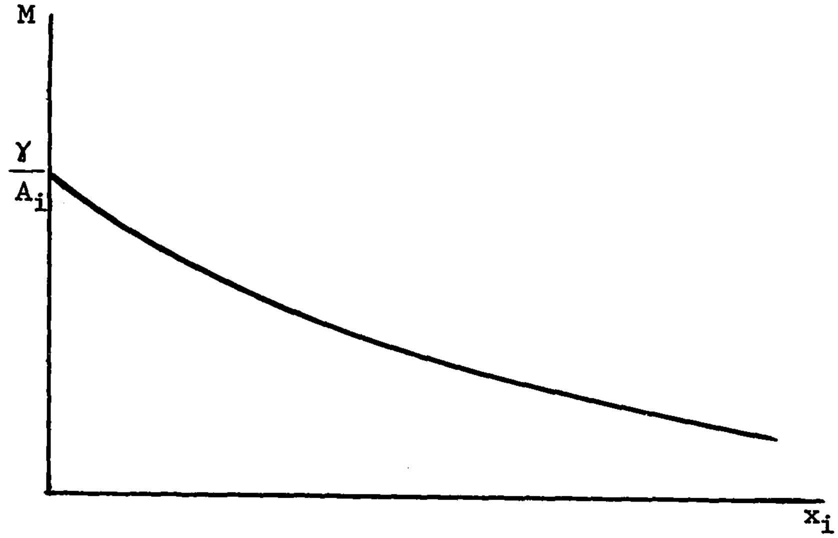
b) $e_i = 1$

As might be expected with the constant revenue conditions accompanying unitary elasticity, the maximum markup can be achieved with output set at the zero level (see figure 10) and $M_o = \gamma_i/A_i$. As in the case of inelastic demand, this finite maximum for M limits the capability of the firm to consider the markup simply as a decision variable. Clearly, a markup in excess of M_o would not produce a

Figure 10

Markup vs. Output

$e_i = 1$



suitable price/output combination under any circumstances when the elasticity is less than or equal to one.

c) $e_i > 1$

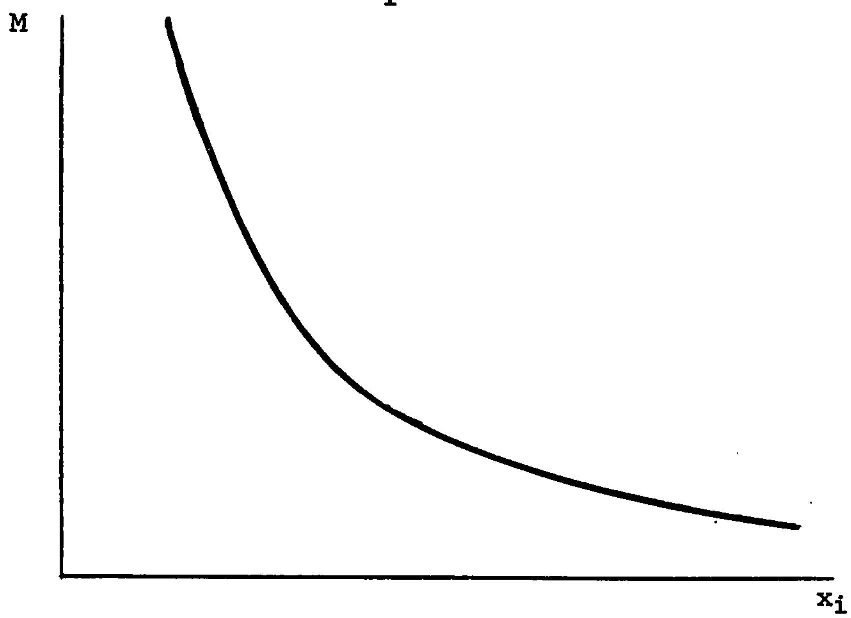
The final case in which elasticity is greater than one (figure 11) does not present the same limitation on the maximum value of M — it can be as high as is desired and still provide a determinate price/output combination. As might be expected under these conditions of elastic demand, the maximum rate of return is infinite and is achieved at zero output.

The constant elasticity of demand situation assumed here is, of course, not realistic. Demand functions for each route will have elastic and inelastic portions. The important factor is that,

Figure 11

Markup / Output

$e_i > 1$



given a variety of demand conditions on the routes operated by the firm, there is a possibility that the markup on cost considered reasonable from the firm's point of view will not be attainable on all routes because it is above the maximum which can be achieved with a finite price/output combination. Hence, a pricing policy based simply on a cost-plus formula, however equitable it may seem for the consumer or the firm, may not always be possible (to say nothing of desirable).

This conclusion also tells us something about the real flexibility of the firm in shifting output from one route to another to cover changing demand conditions. Flexibility must exist not only in the allocation of resources but also in the value of M if the firm is to maintain full capacity utilization in the face of changes in traffic patterns. A firm seeking maximum utilization will have to be willing to change the markup rate as it alters the distribution of capital equipment on the available routes.

B. PRODUCT PERISHABILITY

Firms in the transportation business do not have an inventory carrying capability. Too much capacity implies wasted resources in the form of underutilised capital equipment. Too much demand leads to congestion and queueing within the system.[9] This is a problem which is apparent to a certain extent in relation to other products, particularly electricity generation and the telephone system. In the case of electricity, the presence of too much demand is a most significant problem, and is one to be avoided even if the cost is high. Over-loading the system is likely to lead to total breakdown rather than just a decreased level of service as is the case in telephone and transportation systems. In the telephone system, the number of users and the short length of the demands generally means that service levels are not low for a significant length of time. The exceptions (such as Christmas Day) are obvious and well known to all the users, and the customers are able to adjust

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[9] A. A. Walters, "Characteristics of Demand and Supply," Symposium on Theory and Practice in Transport Economics (Paris: Publication de l'O.C.D.E., 1964), p.233.

satisfactorily. (One exception to this general case of reasonable service levels appears to be New York City, where facilities have not been expanded fast enough to meet the growing demand.) Transportation falls somewhere in between the two.

There are, in fact, two dimensions to the problem of perishability. The first is the inability of the firm to produce seats for passengers or space for commodities for use at some time in the future. Production cannot be stored. This sharpens the need for accurate forecasting and planning in order to avoid wasted output.

A second dimension is the perishability of demand. The distinction between transportation and other industries in this respect is not as clear cut. There are many cases in which there is a very definite time factor in the demand for any product, such as Christmas cards and umbrellas on a rainy day. The key difference comes in the combination of perishable supply with time-dependent demand. Demand for most products can be "stored" for some period of time, and the product can be acquired when it is convenient. Transportation has the same feature, with the maximum storage time depending on the nature of trip, which may vary from a few minutes (rush hour train service) to a number of years (a pleasure trip with no definite objective). The duration of the possible storage helps determine the size and duration of peaks in demand and the general production requirements for the firm. In a market where demand is mostly pleasure travel which has a long "storage" period, the firm's inability to store its product may not be a serious disadvantage to its operations - the consumers will generally fit themselves in with any schedule offered. However, many other markets exist with a type of demand which is more difficult to meet. In the case of airlines, the demands of a short duration are those which arise as a result of a specific unforeseen event such as a sudden business requirement or a family matter. Most pleasure trips are planned much further in advance with the result that allowance can be made for some alteration in the times of arrival and departure.

Airlines take some cognizance of the various characteristics of different types of demand through their pricing structure. In many industries, the output is priced with considerable attention paid to the size of the order made by the customer. Volume discounts are a common phenomenon if not a shibboleth in our society. But this does not seem to be the case for air travel where the most frequent travellers are businessmen. No consideration has yet been given to reduced fares for them. In fact, the lower fares which have been instituted (21-day excursion, Inclusive Tour, Youth Standby) are designed specifically for the non-business market. The kind of volume discount which is available for air travel is applied to a large number of people travelling together, as a charter or group fare. The usual type of volume discount in other industries is based on demand over a period of time during which production need not change to meet every change in the market. To an airline, irregular travellers, no matter how frequent, are irregular travellers and cannot be planned for. Therefore, there is no economy in a large number of trips spread over a period of time if they are not known and scheduled for in advance.

Because the airlines do not find it possible to carry an inventory of their product, they have no opportunity to smooth out their production cycle by accumulating a stock of goods. As previously mentioned, the peaks in production must coincide with the peaks in demand. This highlights the problems associated with highly variable demand which are so obvious in the transportation industry, and is the reason for the efforts to smooth production which result in off-season, shoulder, and peak month fares. The thrust of the fare variety is aimed at those potential travellers whose demand has a longer "storage" period. Any shifting from peak to off-peak periods is a potential area of cost saving for the company up to the point where no additional capacity is required to service the peak. There is some requirement for maintenance and training which allows some "no cost" variation in the capacity offered so that some cyclical pattern in the demand can be tolerated.[10]

The passengers who can postpone or advance their travel to non-peak times may be rewarded with a lower fare than they would otherwise have to pay. In return, they accept a slightly different product in the form of travel at another time than that which would have been most desirable to them.

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[10] J. L. Grumbridge, Marketing Management in Air Transport (London: Allen & Unwin, 1966), p. 27.

The existence of such a high degree of product perishability increases the significance of the uncertainty of demand for the product. We see here a similar relationship to that which exists for many other products, for example theatre productions and perishable produce. In all these cases, production is essentially complete before the goods are actually purchased - the theatre company begins practises, the farmer plants his crops, and the airline plans its schedule well in advance of the actual date when the product will be consumed. Of course the firm will not likely be completely ignorant of the possible demand for the final output, but there will be some uncertainty about the final level. The producer proceeds on the basis of expected values.

In air transportation, the producer sets his output level in terms of frequencies (and, by implication, seats) on a route, and estimates his revenue by making some assumption about the percentage of this output which he will sell, calling this his expected load factor. In so far as is possible, he will try to provide a number of frequencies which will result in an optimal load factor from his point of view. What this load factor should be is not always entirely clear, for its optimality is dependent on the nature of demand which uses the flight.[11]

As the hour of the flight approaches, the probability of achieving the original expected load factor which was used for planning may no

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[11] Anthony H. Milward "Wasted Seats in Air Transport" Journal of the Institute of Transport (May, 1966), p. 349.

longer be relevant. In general, the airline has three courses of action which it can follow if the load factor deviates from the expected level - it can cancel the flight when the load factor becomes too low, it can add capacity (when available) if the demand exceeds expectations, or it can do nothing. As a rule, the third choice is followed in the vast majority of cases, because the airlines count on compensating for their low load factor flights with a similar number at high load factors, thus maintaining the average close to the planned level.

Because of the perishability of the product, the airlines recognize the waste involved in allowing too many flights to depart at load factors below the planned level. This is one of the reasons behind the stand-by fares offered to various groups at various times by airlines in different parts of the world. Stand-by passengers shoulder some of the airline's uncertainty and are offered a lower price as a result.

C. PRODUCT DEFINITION

The utility of the product transportation is derived from the characteristics which it possesses.[12] Different kinds of transportation represent different goods to the extent that there is some variation in the attributes or characteristics of the product as they are

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[12] This theory is developed for commodities in general in Kelvin J. Lancaster, "A New Approach to Consumer Theory", Journal of Political Economy, Vol. 14 (1966), pp. 132-157.

perceived by the consumer. There is a "satisfaction vector" for each consumer which is based on the ability of the attributes to fulfill his requirements.

If the concept is applied to air travel, the relevant attributes will include such things as the trip destination (which will be of prime importance in most cases, but may be less significant for vacation travellers), the departure time, the time of arrival at the destination, the elapsed time necessary to make the voyage, the level of service or comfort, and the mode itself. Substitution does not take place between different goods, but between the characteristics of the goods.

Consider, for example, the question, "Is a flight at one o'clock in the afternoon from Montreal to Winnipeg the same good as a flight two hours later at three o'clock?" The answer is entirely dependent on the "satisfaction vector" of the consumer, which will evaluate the importance of time to him. To some, the time difference will be all important; to others, insignificant. A complete division of commodities into distinct goods is only possible for a single consumer or a homogeneous group of consumers who all have the same satisfaction vector. This assumption of homogeneity is one of the simplifying assumptions which Lancaster makes when he says "... each consumption activity produces a fixed vector of characteristics...".[13] There are deviations from this assumption apparent in every day life, of course, but one aspect of the variation which

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[13] Ibid., p. 135

exists in passenger transportation is particularly interesting. From the consumer's point of view, one of the elements of the vector of characteristics is not completely determined until the journey is actually underway. This factor is best summed up in the word "service". This component is related to the congestion in the system which, in the case of an airline, affects flight choice, access time, seat comfort, the quality of passenger service, noise level, flight time (if the system is so full that air traffic control is inadequate), and egress time. Together, all these factors represent the disutility experienced by the passenger as a result of the relationship between the total demand and the production level chosen by the firm. This disutility varies because the stochastic nature of the demand placed upon the system makes an exact matching of demand with supply impossible, and also because the firm's policy is usually one of maintaining a fixed schedule with fixed capacity.

The variation in demand is incorporated into the planning system of the firm and into the expectation of the customer. Both producer and consumer have an expected level of service which should, on the average, be met. If supply could be exactly matched to demand, this variability would be eliminated, the customer could know what the service level is, and the company would then have eliminated the uncertainty it faced with respect to the amount of revenue per frequency which it could expect. The same amount of revenue could be gained in a number of ways by lowering the price per passenger and operating the existing aircraft completely full, or by improving the aircraft seating and service arrangements and charging slightly more. If a number of types of service at different prices were offered, the consumer would be able to choose more exactly the vector of attributes which appealed to him. At the present time, all the passengers are mixed, so that only some individuals can be said to be consuming the product they wish (or anticipate) on a regular basis. The airline tries to strike a balance - offering sufficient quantity to meet the service expectations of some while keeping price low enough for others, meeting the "average" customer's service requirements in the largest number of cases.

If the firm is successful in achieving the desired level of service (on the average), there will be some proportion of the customers who will feel that they have not received the product for which they paid because they flew under crowded conditions, received worse than average service, but still paid the same fare. If the firm had a dynamic, flexible price policy, the cost to the passenger could have been lowered and still provided sufficient revenue. There will be a similar number of passengers on other flights who paid less than they might have had to if the price were set by the demand conditions for each flight. If the airline designed its pricing procedure to obtain a constant level of income to cover the costs of each frequency, the price/passenger relationship would be represented by a rectangular hyperbola (figure 12). The relationship between the level of service and the number of passengers, however, would be more adequately described by the behaviour of a queueing system (figure 13) where there is a small deterioration in service up to some critical level, Q_A, after which the quality of service deteriorates rapidly.

Figure 12

Average Revenue vs. No. of Passengers
(Total Revenue Constant)

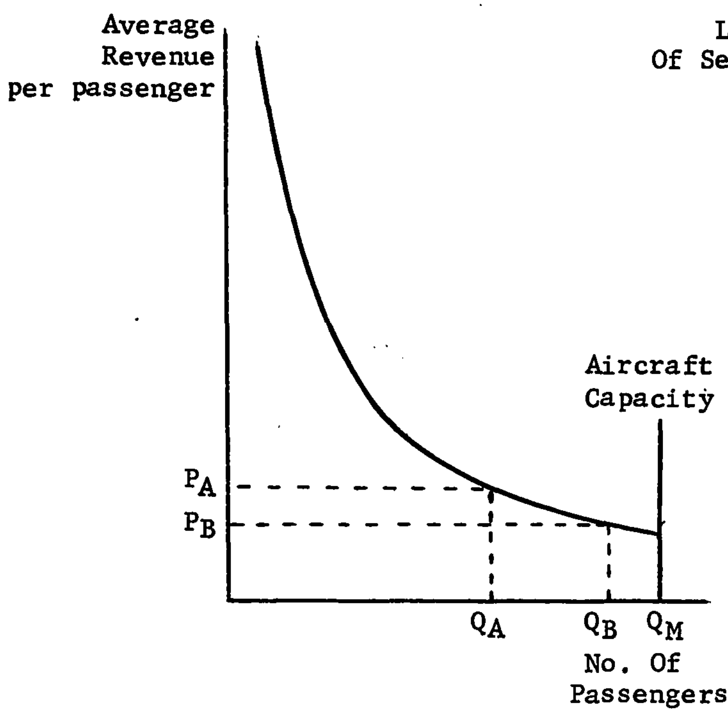
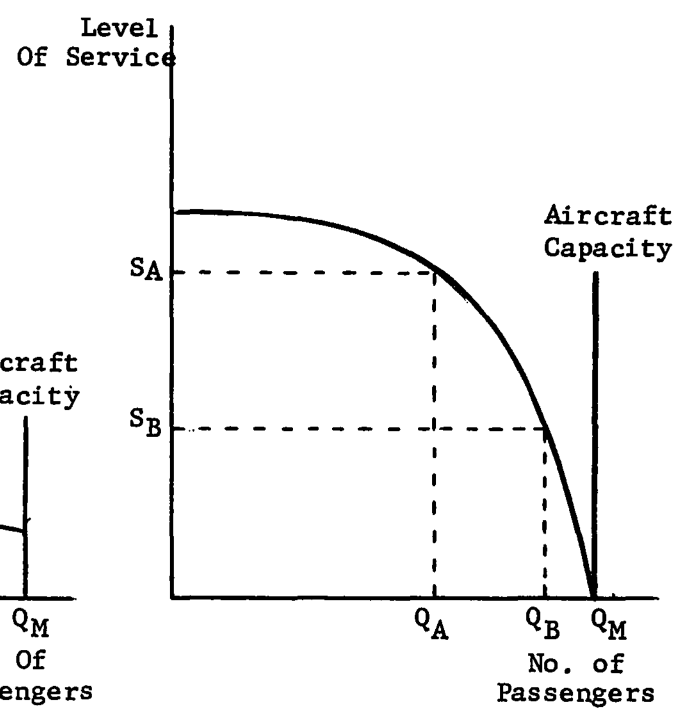


Figure 13

Service Level



Comparing the rate of change of the function in the two charts, it is apparent that at some point the rate of deterioration in service will exceed the rate of decline in the average revenue per passenger. At some point such as Q_A, the period of most rapid decline in average revenue per passenger has been passed, while the range of fastest deterioration in service has not yet begun. Taking this as a starting point, how can the airline relate the fare level to the rapidly deteriorating service level when the number of passengers is greater than Q_A? Because the service level as shown here simply as a measure of utility, not as a monetary unit, no direct comparison can be made. The airline faces this difficulty, but they must make a choice based on some assumption about the trade-off between reduced fares and reduced service levels in order to plan capacity in relation to total demand. It can be expected that the point chosen will have as low a rate of deterioriation in service level as is possible with a low rate of change in average revenue as well. The point Q_A can be considered as an example which meets these conditions. If the level chosen were Q_B rather than Q_A, the change in service would be relatively large (S_A - S_B) compared to the reduction in price (P_A - P_B).

In this area, airlines work by rules of thumb. With no real evidence available on the variation in levels of service with changes in load factor, they cannot make decisions based on firm knowledge of customer reaction. If the planned load factor is achieved and costs are covered without an inordinate number of complaints, the results are considered reasonable.

The reasonableness of the results will be determined by the distribution of load factors which are experienced. Preliminary research into the behaviour of load factors indicates two major types of distributions depending on the sample taken.[14] It is possible to

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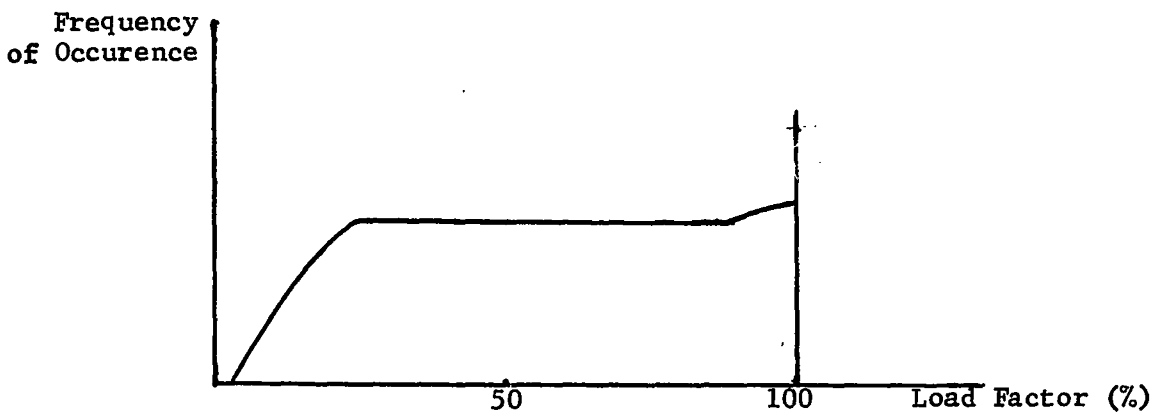
[14]The research referred to here was conducted by Dr. I. Elce and Mr. J. G. Gagnon of Air Canada and is unpublished.

look at two types of statistics - first, the statistics related to the operation of the entire schedule; and second, the load factors realized on a single flight over a period of time.

The information used as a basis for the study of overall load factor distribution was a 5,000 item random sample from all flight legs in the Air Canada system in 1965. When plotted, the statistics presented a picture like figure 14.

Figure 14

Load Factors - Schedule Sample



The distribution is somewhat rectangular, with the exception of the extremities. The higher number of occurences of load factors in the 90% to 100% range was assumed to reflect the number of times the demand was greater than the capacity offered. Because the flights could not be filled beyond this limit, these flights became part of the sample in the 90% to 100% range.

It is difficult to draw any firm conclusions from this

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[14]The research referred to here was conducted by Dr. I. Elce and Mr. J. G. Gagnon of Air Canada and is unpublished.

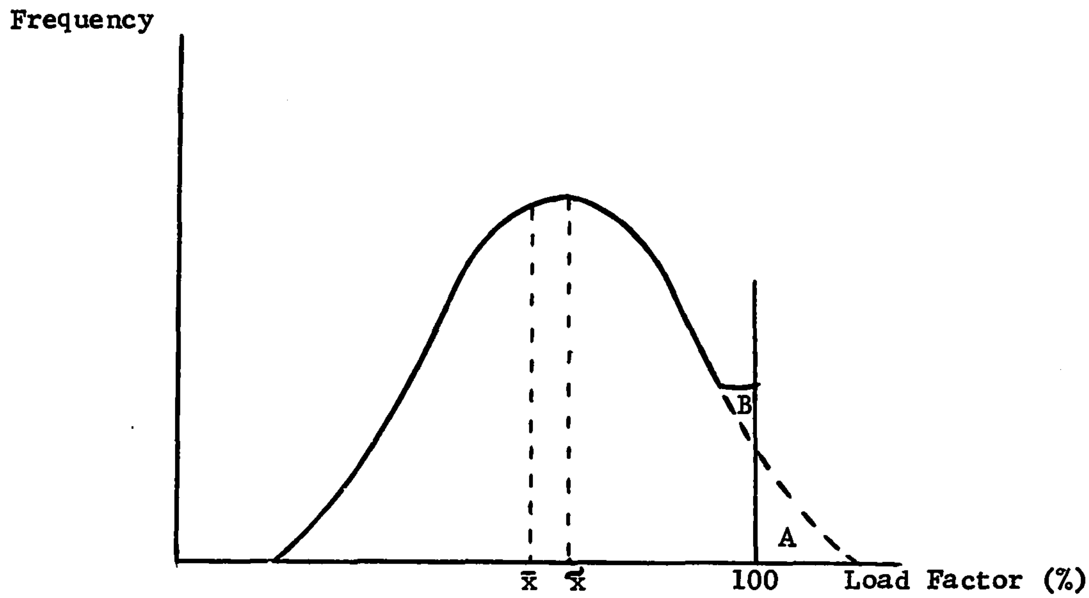
distribution about the level of service being experienced by the passenger. It is reasonable to assume that the consumer would receive a better level of service on the average if some of the flights which operated at lower load factors could be transferred to the times or routes represented in the high load factor range, thus giving the distribution a more "normal" shape. The shape of this distribution, taken in conjunction with the distribution of load factors for a single flight, indicates that the low load factors are concentrated in a few flights rather than spread evenly over the schedule. This suggests that altering the schedule to improve the load factors on these generally less popular flights might add significantly to the overall level of service achieved. Aircraft scheduling is a difficult enough process that one can be sure that the adjustment would not be very simple to carry out, but, in purely qualitative terms, it appears desirable.

Looking at the other possible sample of load factors, it is possible to gather statistics on the load factors experienced on a single flight over a period of time. *A priori*, one would expect that the pattern of load factors might be something like the shape of a normal curve. The relationship actually appears similar to figure 15.

The curve has a normal appearance except in the range of high load factors, where the distribution is truncated and distorted. As with the multi-flight sample, this occurs because it is not possible to have a load factor in excess of one hundred percent.

Figure 15

Load Factors - Single Flight Sample



If demand for any flight is greater than the capacity offered, the flight will operate as if demand were equal to capacity. As a result, the distribution will not appear normal in the region of high load factors. If it is assumed that the distribution would be normal if the capacity were not restricted, then the lower half of the distribution can be used to characterize the whole.

To do this, Elce and Gagnon[15] estimated the variance of the distribution (S^2) using the median as an estimate of the mean:

$$S^2 = \sum_i (X_i - \tilde{x})^2 / (N/2)$$

where X_i represents the i^{th} observation below the median and N

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15 *Ibid.*

is the total sample size.

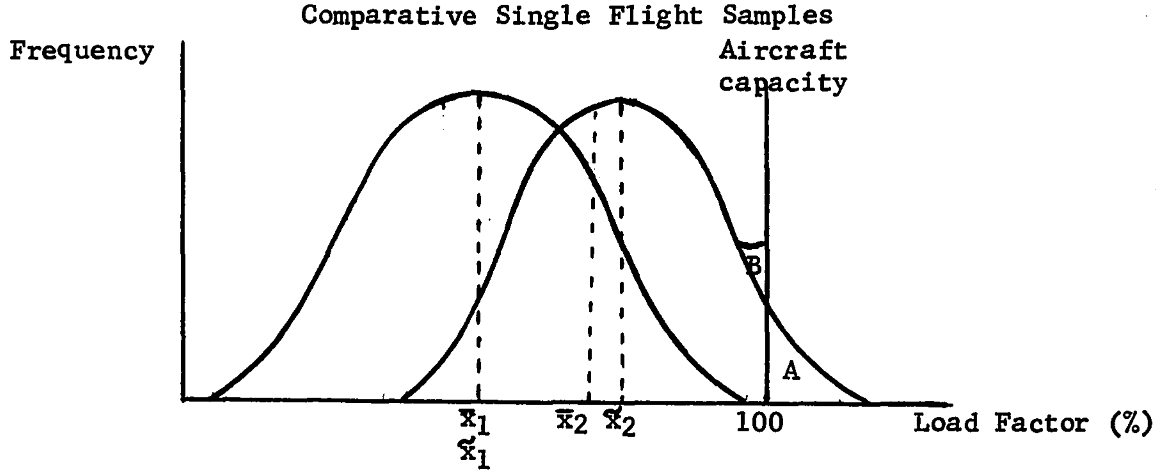
Using medians and standard deviations thus derived, they then examined the relationship between the average load factor and the standard deviation, and found that a linear relationship

$$S = \alpha + \beta \tilde{x}$$

was the most appropriate, with the α coefficient being insignificant. With this relationship, it becomes possible to predict the effect (in terms of lost passengers) of various average load factors. If all flights for which demand is greater than 100% of capacity fly full, then those passengers who cannot be accommodated are "lost". At low average (mean) load factors (like $\bar{x}_1$ in figure 16), the range is not large enough to include any situations where demand exceeds capacity, so the mean is the same as the median. As the demand increases, and the median load factor goes up, some passengers are "lost" because they cannot be accommodated, and a divergence occurs between the mean and the median load factors ($\bar{x}_2$ and $\tilde{x}_2$) as a result because A> B in figure 16.

Figure 16

Load Factors
Comparative Single Flight Samples



This type of passenger load distribution results in reduced service levels as a result of two factors. The first is the number of passengers who cannot be accommodated in the system (the "lost" passengers). The second factor is the larger number of high load factor flights than a strictly normal distribution would suggest. Therefore, because service is more than proportionally worse at these levels (figure 13), the dissatisfaction of the mean passenger is increased.

It should be pointed out that the "lost" passenger is one who inconvenienced by the schedule so that he is not able to get a seat on the flight on which he wishes to travel. As a result of this congestion in the system, he may either choose another flight or decide not to fly. The "lost" passenger exemplifies the possible reduction in service and increase in disutility which can result from imbalance between the supply of and demand for transportation.

Of course, other passengers besides those who are "lost" experience inconvenience and the resulting disutility as a result of the number of people trying to get from one place to another at the same time. With output and demand reasonably matched, this disutility will be negligible, but it can increase rapidly as congestion increases. Disutility can be considered to be a cost above and beyond the operating cost of the transportation firm, reflecting the fact that the actual product which is available to the consumer is a function of the number of people in the market place relative to the quantity of production. These are important costs. With increasing congestion, "costs to the operating agency may be very little affected, and in this sense, one might say that the marginal cost is very low; the cost, however, is to be measured in terms of the deterioration in the value of service to the former passengers."[16]

Each ticket purchased for a trip has an effect on the product received by all the passengers whose fare has already been paid. These external effects of increased demand for a journey are compensated for to some extent by changes in the expectations of the customers based on their imagined or observed image of the market conditions at the time of travel. For instance, trips made at busy times of the year (or week, or day) are expected to be accompanied by special conditions. People anticipate that travel facilities will be crowded on the Labour Day weekend and change their outlook according. Sometimes the expected conditions are not, in fact, the actual conditions and the passenger may be surprised by either the ease or difficulty of his passage.

Similar conditions exist in many areas of modern living, particularly in or near urban areas. Road congestion, crowding in stores and public parks, and other places where groups congregate can affect the quality of the product received by the individual. The situation in public carrier transportation is a good example of this congestion condition which occurs frequently and in relation

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[16] Wm. Vickery, "Some Implications of Marginal Cost Pricing for Public Utilities," Transport, Ed. Denys Munby (Baltimore: Penguin Books Inc., 1968), p. 113.

to a product for which direct monetary outlay is necessary. The consumer is a paying consumer, not a user of public good financed out of general tax revenues, as parks and roads are likely to be.

Because the variation in demand for transportation is not completely random, the firm can do something to adjust production to expected demand. The desire to maintain some standard of service in the form of additional capacity will increase overall costs above the minimum necessary to meet a known level of demand. In different transportation industries the planned level of excess capacity may vary, but it is always there, based on the firm's calculation of the service level expected by the public and its relationship to price and revenue.

The actual method used to calculate a suitable allowance in capacity for uncertain demand is not clear in any transportation enterprise, but the results of the phenomenon are observable in the market place.

IV OPERATING COST AND CONSUMER DISUTILITY

A. MODEL DEFINITION

To develop a function which adequately reflects some of the important features of supply and demand for transportation, it is necessary to meet two difficult problems which do not arise with the same severity in other industries. The first is the basic difference between the commodity produced by the transportation firm and the product purchased by the consumer.[1] Some method must be found to accommodate the different units in the same framework, so that supply and demand, and cost and revenue can be equated. Secondly some cognizance must be taken of the nature of stochastic demand and perishable supply. It is not reasonable to analyse the behaviour of the transportation industry in terms of known, unvarying demand in relation to supply. Even if the system is not explicitly stochastic, it must at least be designed to incorporate the characteristics of such a system so that the effects of variations in demand can be seen.

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[1] See E. Troxel, Economics of Transport (New York: Rinehart & Company, 1955), p. 93, and G. W. Wilson, "On The Output Unit In Transportation," Land Economics, Vol. 35, No. 3 (Aug. 1959), pp. 266-76.

An airline's production is based on a schedule of aircraft frequencies which provide a number of seats to the public at a single point in time. The sale of tickets is usually made on a price per seat basis, so that production is not sold as a unit and, on average, will only be "partially" consumed. The nature of the production process is such that the unsold production cannot be stored to improve the production/consumption balance. In addition, the frequencies produced do not provide the flexibility necessary to handle demand which exceeds the maximum expected. Thus, the transportation firm has the task of finding the middle of the road between two extremes. On the one hand, the provision of sufficient capacity to handle virtually all the demand in all cases is prohibitively expensive because it implies an average load much smaller than the capacity of the schedule would permit. On the other hand, to maximize the utilization of the equipment at a one hundred percent load factor, the firm would have to offer capacity at a level far below that which was demanded by the public. Between the maximization of consumer service (at high price and low load factors) and the maximization of equipment utilization, there is some level of service which provides the best balance for producer and consumer.

How should this balance be achieved? One conception of the problem is suggested by Professor A. Walters for the handling of freight.[2] He postulates demand for output as a function of price

[2]"Characteristics of Demand and Supply" in European Conference of Ministers of Transport, <u>International Symposium on Theory and Practice in Transport Economics</u> (Paris: O.C.D.E., 1967), p. 232 - 247.

(p) and service (S):

$$X = X(p, S)$$

To define the notion of service (S), the demand for output, X, and the capacity, Y, must be considered:

$$S = S(X, Y)$$

The cost of production is also a function of output and capacity:

$$C = C(X, Y)$$

With demand and cost defined, the price/output combination which maximizes profit (P) can be found, but it must be done in terms of both output and service rather than just output.

maximize $P = pX - C$

Differentiating with respect to X, and with respect to Y:

$$dP/dX = (dR/dX) - (dC/dX) = 0$$

and $$dP/dY = (dR/dY) - (dC/dY) = 0$$

Equality of both equations is required for profit maximization. The marginal revenue of output is equal to the marginal cost of output, and the marginal revenue of capacity is equal to the marginal cost of capacity.

The important feature of Walters' analysis is the relationship among service, capacity, and output. The same output can be produced using different combinations of service and capacity (i.e. many small trips or fewer large trips), and the same capacity can be used to provide different combinations of service and output. Because there is a trade-off between capacity and service, any positive level of demand for service restricts the firm's capability to get maximum output from its capacity. As a result of these service considerations, the firm engaged in transporting goods must change its behaviour from that which might be considered rational in other circumstances. "If the choice of a certain capacity is defined as equivalent to the choice of a plant in the accepted theory of the firm, the businessman (or haulier) will always choose a bigger plant than he would when there are no considerations of service".[3]

When service is considered as a part of the production process, it is necessary to look further than a simple matching of supply with known demand (see above, page 64). Fluctuations in demand can be anticipated and planned for to some extent at least, despite imperfect knowledge of the size and importance of the variation.

For freight traffic, some flexibility is available because the goods being handled are usually inanimate, so they can be shifted, stored, and processed at the convenience of the transporter, constrained only by his need to meet overall service levels. Passenger traffic is less passive in the face of delays, able to move itself around, make its demands known, and attempt to route itself through the system. The transport firm's flexibility is thus somewhat reduced. In order to plan its output level and determine the price of its product to the consumer, the firm must consider its own costs and the costs perceived by the consumer which are dependent on the relationship between supply and demand.

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[3] *Ibid.*, p. 237.

For the airline, the cost of production is determined by the technical aspects of servicing and flying an aircraft and providing all the auxiliary services. To actually determine the cost of production on a given route is a difficult task, and no generally agreed methodology for cost determination exists, However, the form of what might be a sample cost equation can be specified:

$$C_1 = a + bF + cN \qquad (4\text{-}1)$$

where C_1 = operating costs on a single origin-destination

F = number of frequencies

N = number of passengers

a = fixed terminal and servicing costs

b = flying cost per frequency

c = passenger service cost per passenger.

Equation (4-1) represents the total cost which the airline incurs in terms of financial outlay. Strict application of this cost function to output determination would imply that a given number of passengers could generally be transported at minimum average cost by putting passengers on each flight until it was completely full. In such a system, average cost would be minimized but service would be inadequate.

The traveller expects the airline to provide some excess capacity on the average to handle random variations in demand. This is a reasonable expectation. In many respects, the transport system can be seen to have externalities which have to be internalized for the purposes of planning by the firm. One of these externalities is the dissatisfied customer who cannot travel because of the congestion in the system. His inconvenience shows up in neither the costs nor revenues or airline operation, but is nonetheless very real. In addition to the variability of demand, the absolute number of passengers wanting to travel is important as well, because it determines the overall level of activity or "load factor" for the system.

How can this desire for service be expressed as a disutility cost? One method is to consider the cost as a function of the waiting time of the average passenger:

$$C_2 = N\left[d \times \frac{24}{F}\left(\frac{1}{P\{V\}} - 1\right)\right] \qquad (4\text{-}2)$$

where C_2 = service cost

d = cost of waiting time per hour

$P\{V\}$ = probability that each passenger gets on the first flight he chooses, where

$$V = \frac{100 - \left(\frac{N \times 100}{F \times S}\right)}{S.D.} \qquad (4\text{-}3)$$

and S = number of seats/frequency

S.D.= standard deviation of average passenger load factor.

The key element in this procedure for estimating service cost is the use of the probability that a passenger does not obtain a seat on one of the available flights to determine average waiting time.

With a given average load factor, the number of passengers who cannot be accommodated on the scheduled flights is determined by the spread of the distribution, represented by its standard deviation. If the distribution of demand is represented by Distribution A in

Figure 17

Probability of a Passenger Getting Onto a Flight

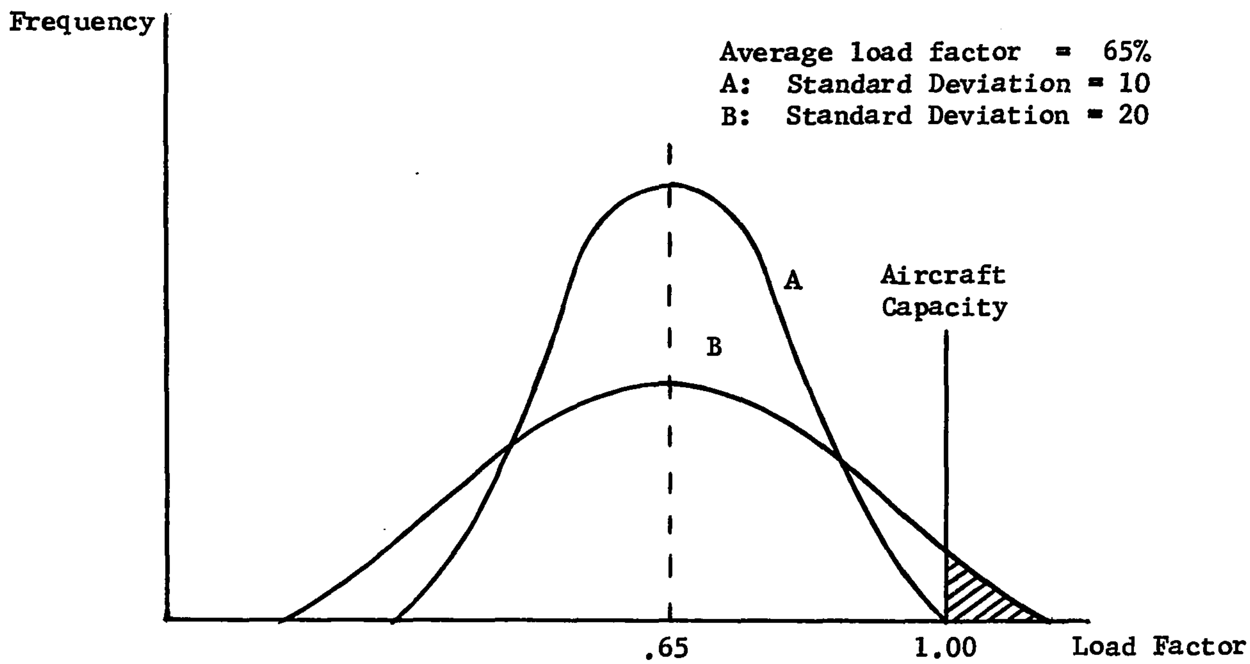


Figure 17, the 65 percent load factor represents a "reasonable" service level. The area of the curve which is above the 100 percent load factor is small or nonexistent. By comparison, a demand distribution with the same average load factor and a larger standard deviation will result in a larger area of curve beyond the capacity of the system. Hence, there is a larger probability that the passenger wanting to travel will be unsatisfied.

To say that the variation in demand is random would not be completely accurate. Some parts of the demand can be shifted without inconvenience or significant cost to the consumer, thus reducing the overall variability in the demand. For instance, any traveller who is indifferent as to the time his trip is undertaken will be able to be accommodated, and whatever flight he takes will represent his "first choice". The traveller may also be more sensitive to price differentials, and this may allow the airline to influence his choice of travel time. As a generalization, one could say that the pleasure traveller is more likely to be flexible in his travel plans so that the pattern of demand for each flight on a pleasure route can be made less variable than might be expected. Conversely, the business traveller may be less flexible, and desire more "over-capacity" in the system to allow him to travel exactly when he wishes.

This difference in attitude will result in a lower probability of waiting, $P\{V\}$, for the flexible traveller in equation (4-2) and, as a result, a lower disutility cost with the same load factor. Besides this variation between business and pleasure customers, the cost of waiting time per hour, d, will be different. This figure is a measure of the opportunity cost of time to the customer. It is hard to imagine completely flexible, placid customer who would consider this opportunity cost equal to zero, but it can be assumed that the average businessman is likely to place a higher value per hour on his time lost than the average vacationer will at the time he is planning his trip.

Using these behavioural assumptions as a basis, typical business and pleasure travellers can be created. The businessman places a high value on any time lost to him because the transportation facility cannot handle him at his preferred time. The demand he places upon the system is irregular and he is relatively inflexible in his demands. As a result, the distribution of demand for business travel has a high standard deviation.

In contrast, those travelling for vacation purposes place a lower value on the time lost due to any difficulty in getting space on one of the available flights. Because plans are more flexible for pleasure trips, the distribution of demand has a lower standard deviation.

B. MODEL SPECIFICATION

For purposes of planning and evaluating the firm's output, both operating costs (expressed by equation 4-1) and service costs (equation 4-2) must be considered. The total cost will include items which represent costs to the consumer (nor reflected in revenues to the firm) as well as costs to the firm, hence:

$$TC = a + bF + cN + N\left[\frac{24d}{F}\left(\frac{1}{P\{V\}} - 1\right)\right] \qquad (4\text{-}4)$$

This equation is not complex in appearance, but the close relationship of the number of passengers, N, and the number of frequencies, F, makes it difficult to evaluate using mathematical analysis. A more direct initial treatment in the form of enumeration of the function on the basis of assumed parameter values is useful to indicate the general behaviour of the equation.

Fortunately, the parameters are defined so that they have some relation to real factors. It is difficult to determine the exact values which would be correct for a specific instance, but some range can be placed on the relevant ones for general consideration.

The value of the fixed cost, a, does not alter the behaviour of the function in relation to changes in frequency and demand. As a result, it is unnecessary to give it a monetary value for the general case. It is therefore set to zero.

Each frequency has a cost of operation, b, which is incurred whenever a flight is made. Once the aircraft type is known, the route characteristics may be assumed to determine the cost of the frequency to a large degree. The figure used here is based on a basic cost of $550.00 per flying hour which is applicable for a modern aircraft type such as the twin engined Douglas DC-9. For a three hour trip, covering a distance of approximately fifteen hundred miles, the flying cost would therefore be $1650.00. Hence:

$$b = 1650$$

The other element of operating expense is passenger service. This includes only the amenities which the airline provides for each passenger - things such as food and other passenger comforts, as well as insurance. It is assumed to be directly proportional to the number of passengers flown. This figure will vary depending on the length of the flight, but for a three hour trip, the expenditure will be approximately five dollars per passenger.

$$c = 5$$

This brings us to that part of the equation which considers the overall service level provided by the schedule in relation to the demand as a service cost. Two parameters need to be provided here.

The first is the value to the traveller of time lost. A range of figures will be necessary here because it is interesting to consider different alternatives, and there is no reason to expect that all travellers evaluate the time lost in the same way. In addition, to determine the probability that passengers do lose time, $P\{V\}$, the standard deviation of the demand distribution must be provided. A range is useful here as well.

The range on time value, d, will place it at something greater than zero and less than its highest opportunity cost. It is easy to imagine specific instances where opportunity costs are extremely high, but when this is the case, viable alternatives to scheduled airline travel exist, like chartered or corporate aircraft. A more reasonable estimate can be based on the average wage of the airline business passenger, which might be approximated at fifteen dollars per hour (for a $25,000 a year executive working a thirty-five hour week) to give a reasonable "high" estimate. The minimum may be less than a dollar or two per hour (one hopes it is for stand-by passengers), and a conservative estimate would be five dollars. The initial values for time-value will be

$$5 < d < 15$$

The size of the standard deviation of the demand distribution is a figure which can be readily estimated on the basis of historical information. A very small sample[4] provides values of seventeen,

[4]Three origin/destination pairs (Calgary-Edmonton, Montreal-Chicago, and Toronto-Chicago) in August, 1968 on Air Canada flights.

twenty-one, and thirty; and these can be used as representative of a range somewhere between ten and thirty. This range will certainly be adequate for exploring the behaviour of the cost function.

$$10 < S.D. < 30$$

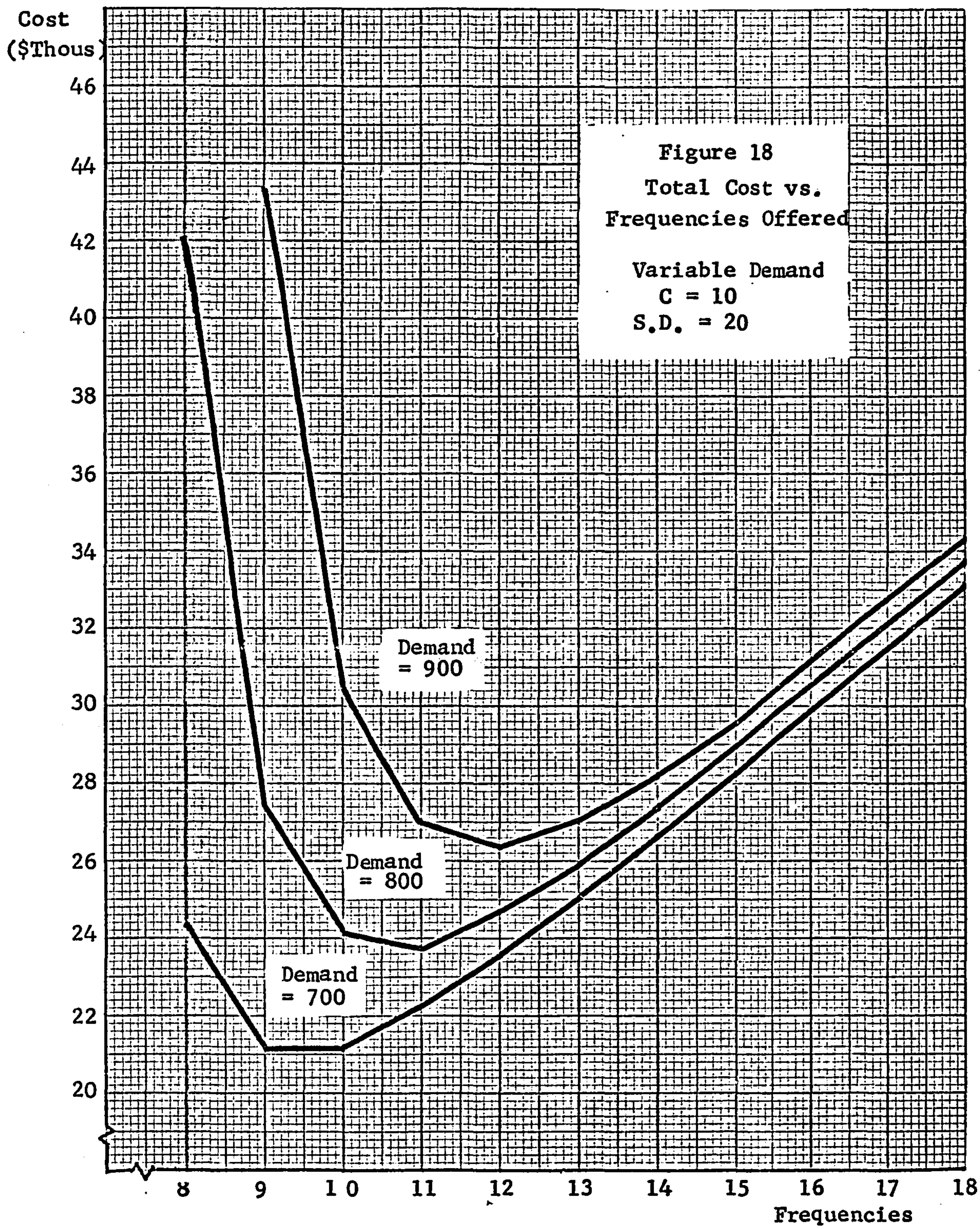
This exercise in parameter estimation provides us with a range of reasonable values for the entire equation. What are the results? Because there are many parameters with ranges on them, the best approach is to consider variations in them one by one - first varying demand, then the value of time lost and finally the dispersion of the demand.

1. Variations in Demand

The level of demand is not really a parameter. The approach here, however, for purposes of cost determination is to consider the number of passengers fixed (at various levels) and find the cost of carrying them on different numbers of frequencies (figure 18). The demand levels at this point are purely arbitrary (700, 800, and 900 passengers are used here). The dollar value of time lost and the standard deviation of demand are constant at ten and twenty, respectively.

The total cost function has a U-shape, so it is a simple matter to pick out the point of minimum cost for each demand level. The shape of the curve is of course not the usual total cost function, due to its incorporation of the consumer disutility. This permits what is technically negative marginal "cost" for part of the frequency output.

As might be expected, the minimum cost level is reached at successively higher frequencies as demand increases. The average load


Cost
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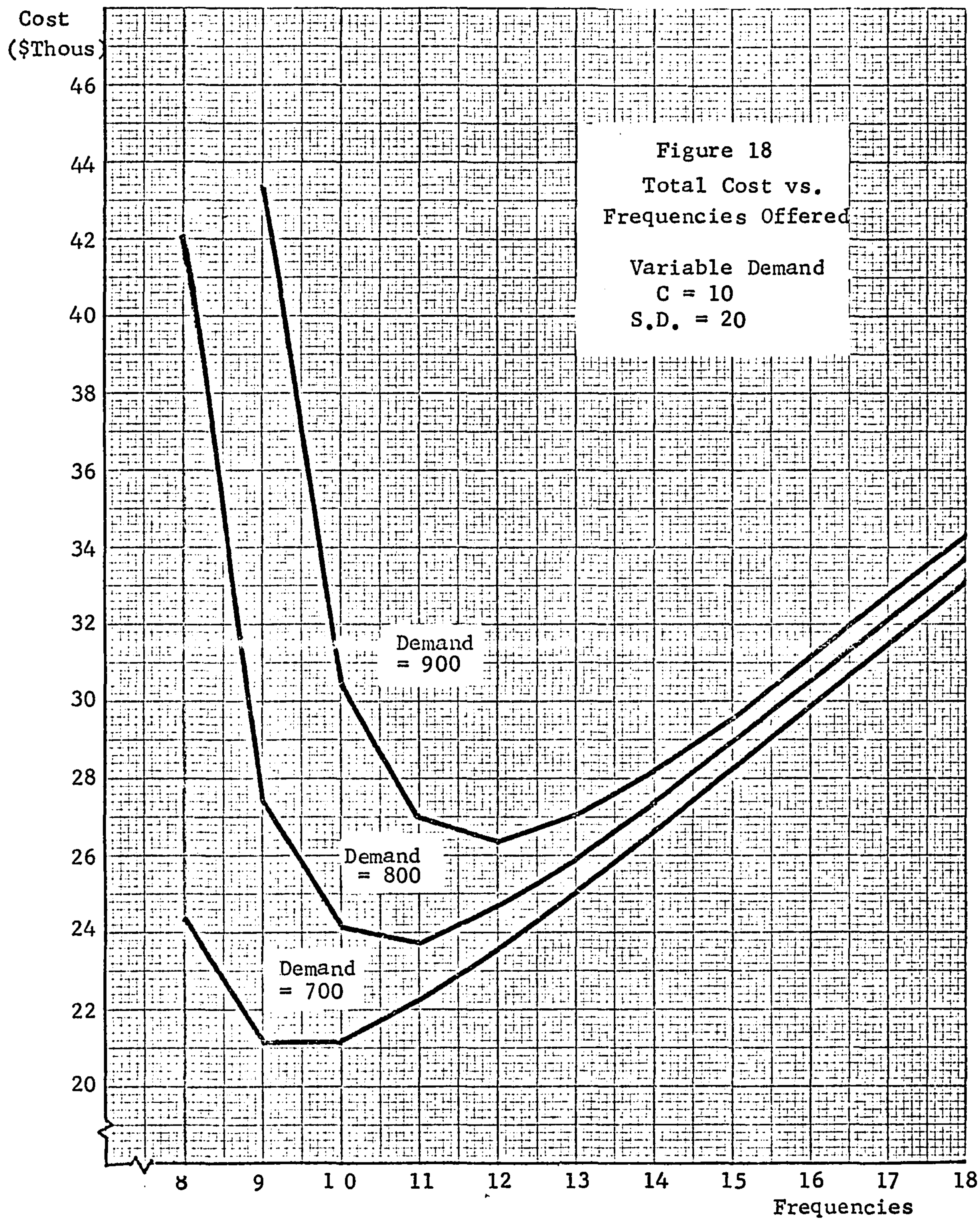
16
17
18
Frequencies
Figure 18
Total Cost vs.
Frequencies Offered
Variable Demand
C = 10
S.D. = 20
Demand
= 900
Demand
= 800
Demand
= 700


Cost
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12
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16
17
18
Frequencies
Figure 18
Total Cost vs.
Frequencies Offered
Variable Demand
C = 10
S.D. = 20
Demand
= 900
Demand
= 800
Demand
= 700

factor at this minimum, however, remains much the same at this minimum cost level - 75 percent when demand is 900, 73 percent when it is 800, and either 70 or 78 percent when it is 700. (The continuity of the function is questionable due to the necessity for providing integer frequencies. Hence, the points have not been joined by a curve.) Once the load factor declines to about 50 percent, and there is only a very small probability that any passenger will not be accommodated on the flight he desires, the lines become parallel. At this point, the part of the function representing disutility cost, C_2 (equation 4-2) is equal to zero, so the slope of the line is b and they are separated by a distance $c(N_1 - N_2)$.

2. Variations in the value of time lost

Fixing the number of passengers and the dispersion of demand illustrates the effect of changes in the value of time lost (Figure 19). Two factors are affected. First, the overall cost level is raised, so the minimum total cost for a fifteen dollar per hour value for time lost is $2,200 higher than for a five dollar per hour value. As the number of frequencies increase, the difference in total cost is eliminated because no passengers incur the cost of lost time.

The second effect is the increase in the number of frequencies necessary to achieve the minimum cost, and the resulting decline in load factor. The load factor for minimum cost production with time value equal to five is 80 percent. For high values, the load factor declines to 73 percent. The type of passengers utilizing the system affects the total cost of transportation and the number of frequencies

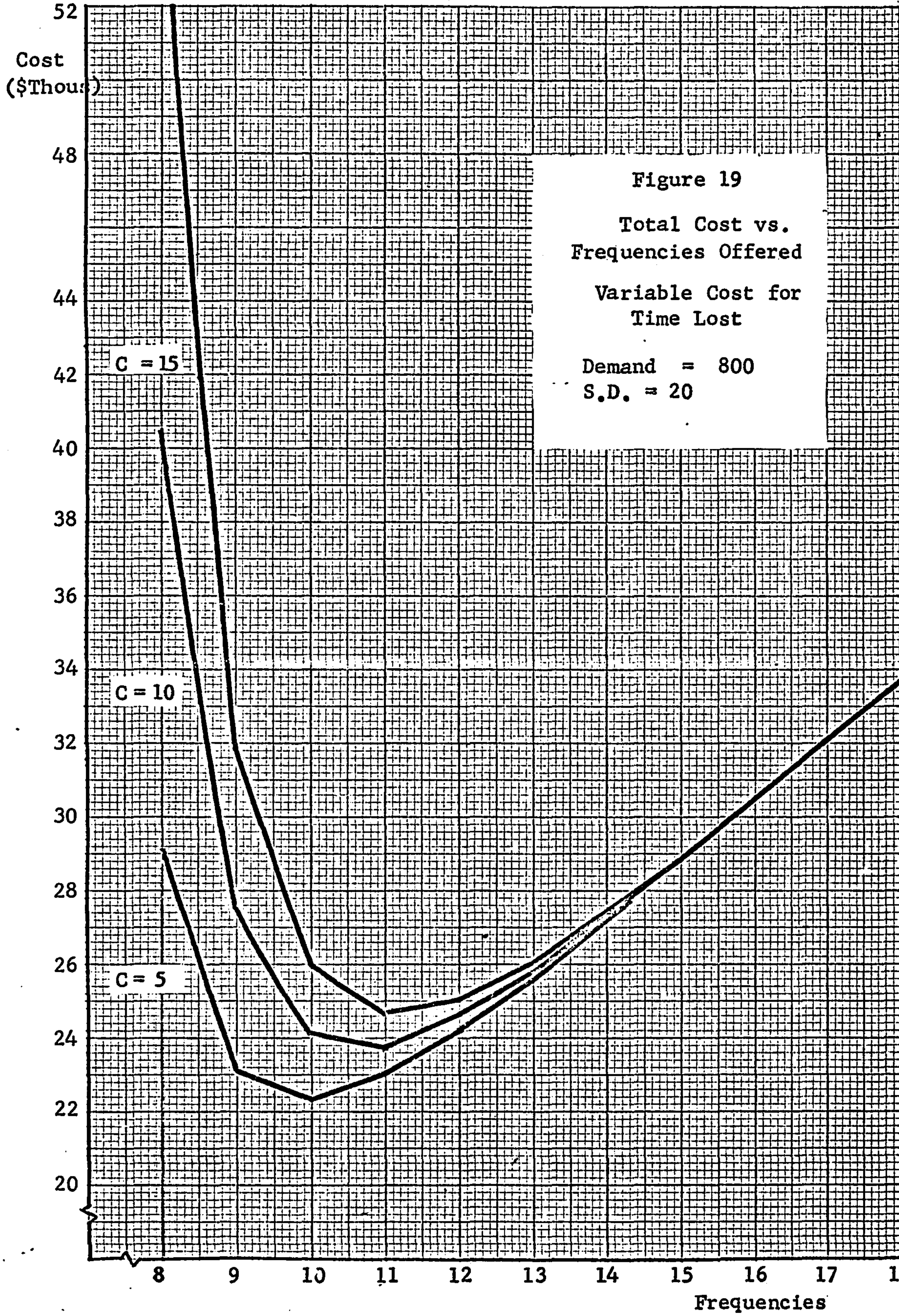


Figure 19

Total Cost vs.
Frequencies Offered

Variable Cost for
Time Lost

Demand = 800
S.D. = 20

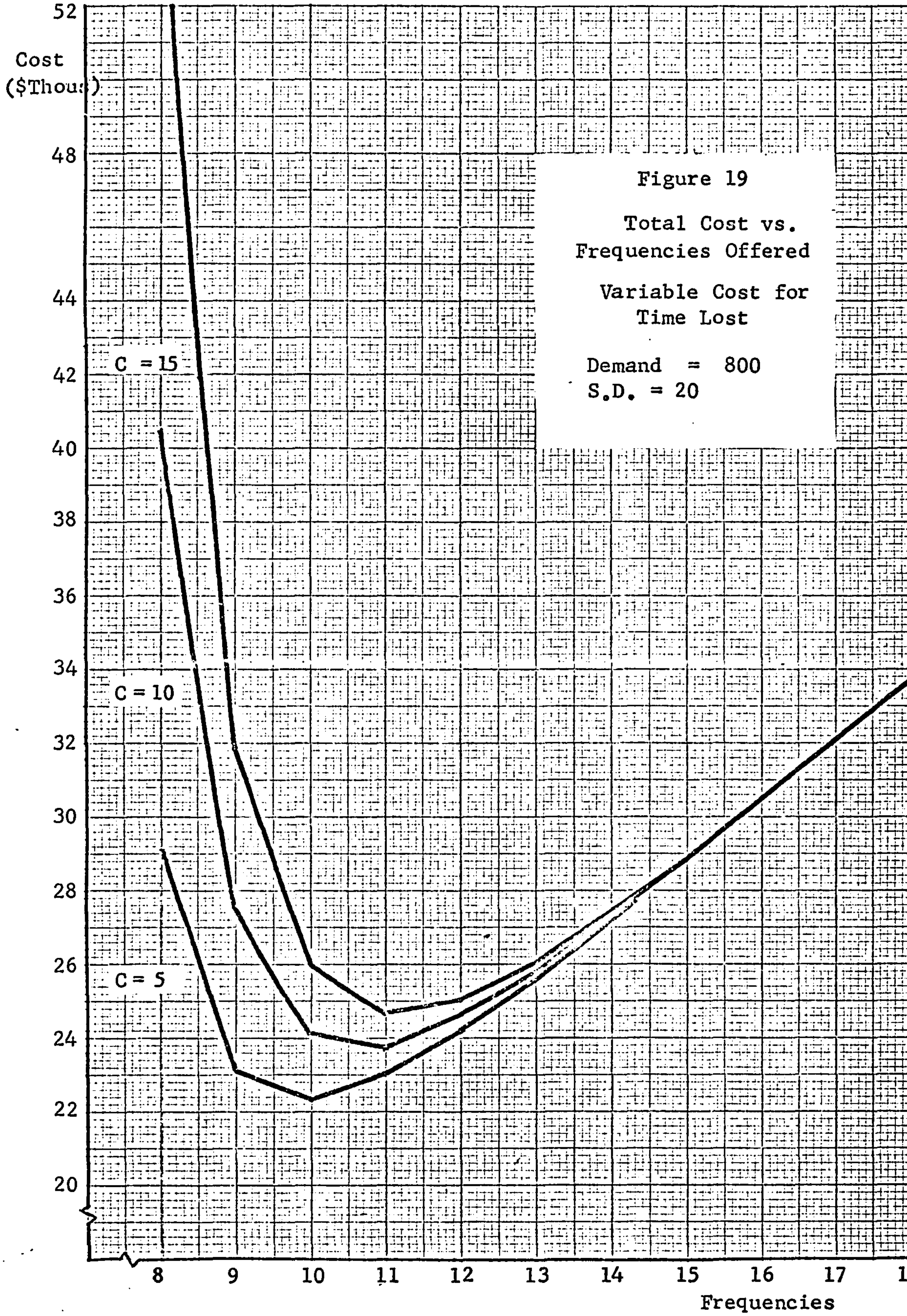


Figure 19

Total Cost vs.
Frequencies Offered

Variable Cost for
Time Lost

Demand = 800
S.D. = 20

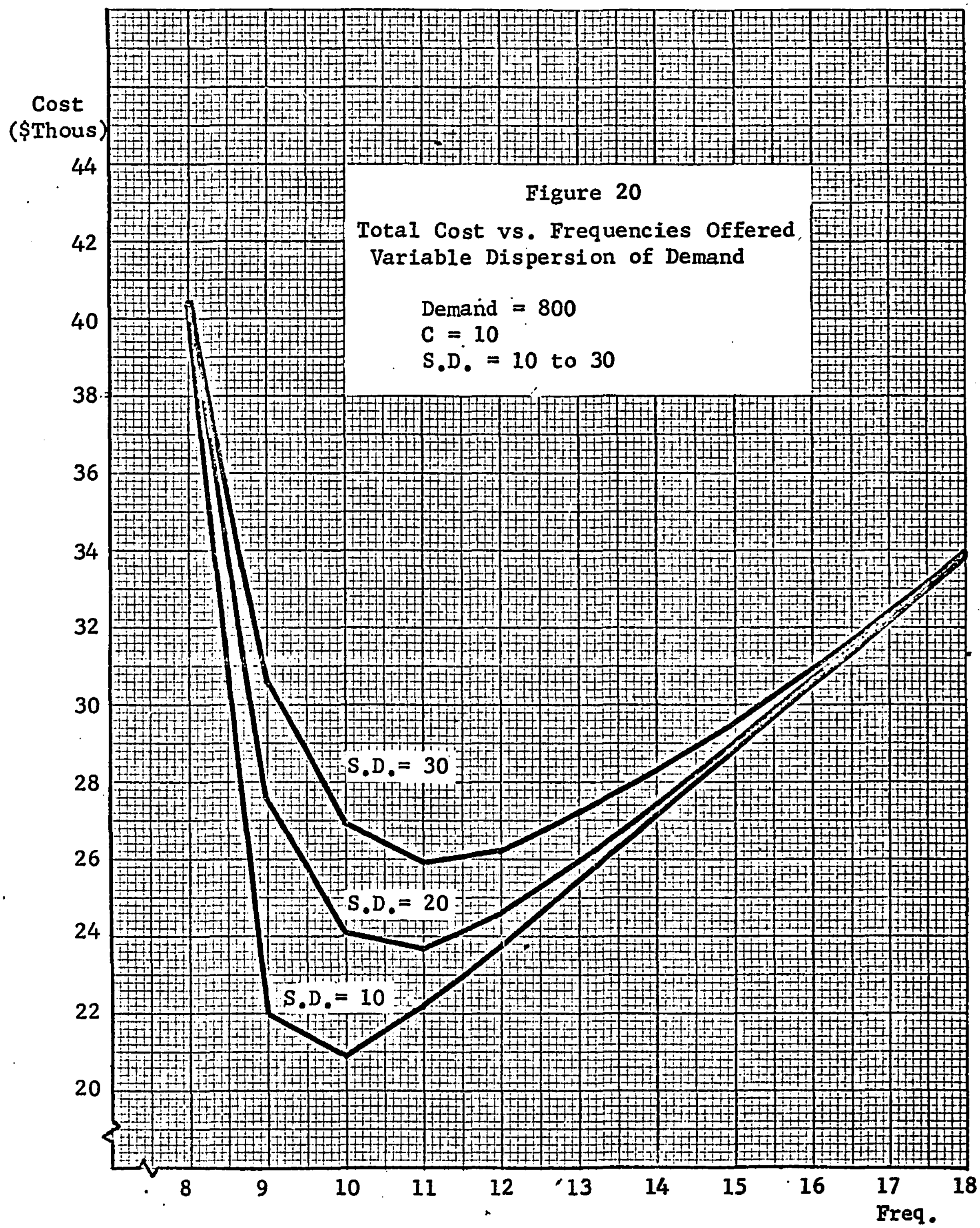
required for optimal service.

3. Variation in the dispersion of demand

Having observed the effect of an increase in the value of time lost, a moment's consideration suggests that an increase in the dispersion of demand would have a similar effect of augmenting the disutility cost, C_2, associated with any level of demand. This is indeed the case as figure 20 shows. The net result is much the same, with the overall increase in cost and the shifting to the right of the point of minimum cost, so it occurs at lower load factors. To meet the passengers' desire for more capacity to accommodate larger deviations in demand, the airline provides more frequencies at the point of minimum cost.

Returning to our original speculations about the relative values of time lost and demand dispersion for two different types of travellers, a comparison can now be made. Figure 21 shows the difference in supply required to carry an equal number of businessmen and vacationers with the best balance of service and operating cost in each case. Because of the high value placed on time lost by the business travellers and the type of demand they make on the system, the cost of carrying them is about one third higher than it is for a group of pleasure travellers of equal size and the number of frequencies required is one third greater as well. The airline which plans for business traffic will offer more frequencies and achieve a lower average load factor than it would for an equal number of vacationers.

The graphs shown in figures 18 to 21 all show the relationship


Cost
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Freq.
Figure 20
Total Cost vs. Frequencies Offered
Variable Dispersion of Demand
Demand = 800
C = 10
S.D. = 10 to 30
S.D.= 30
S.D.= 20
S.D.= 10

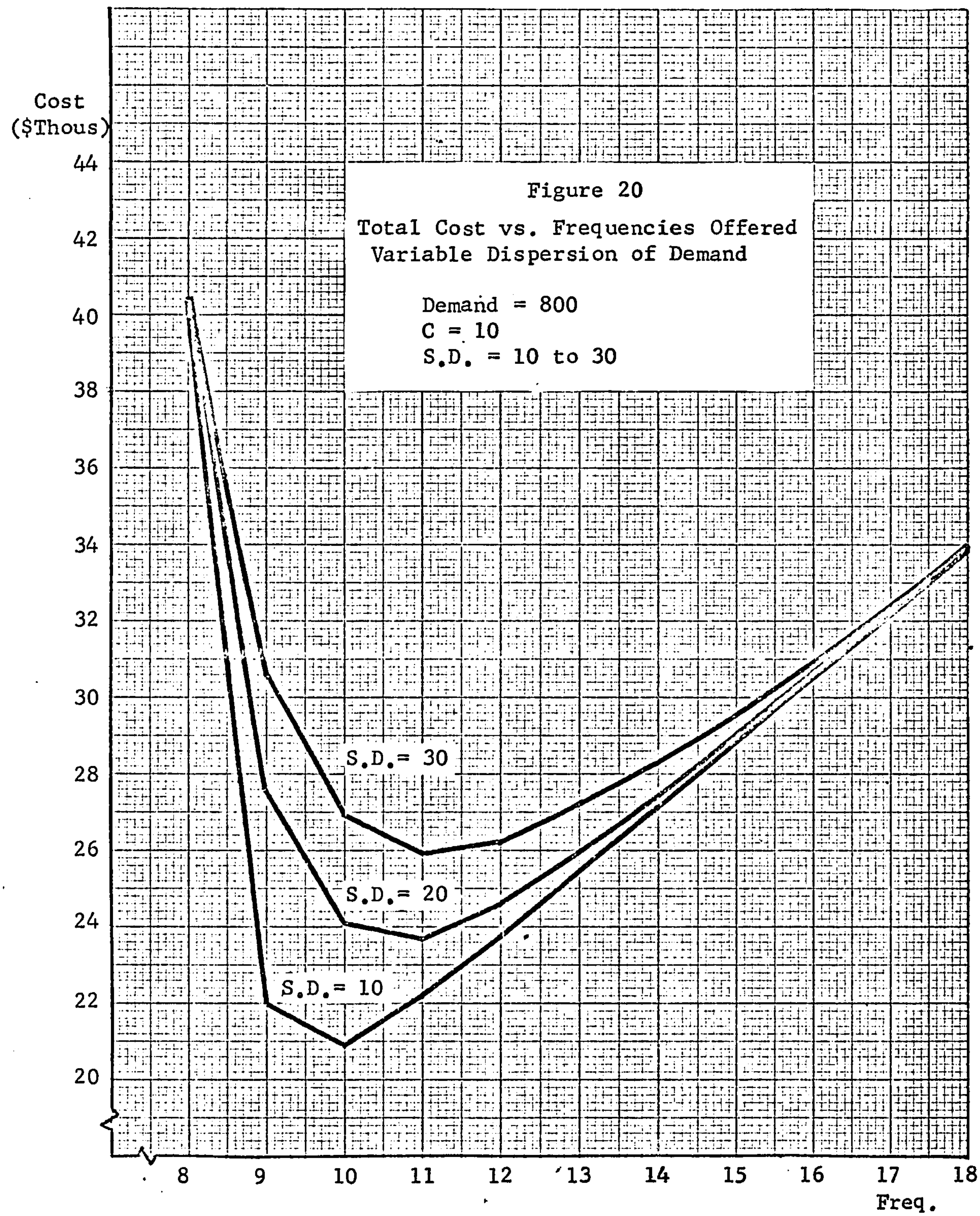
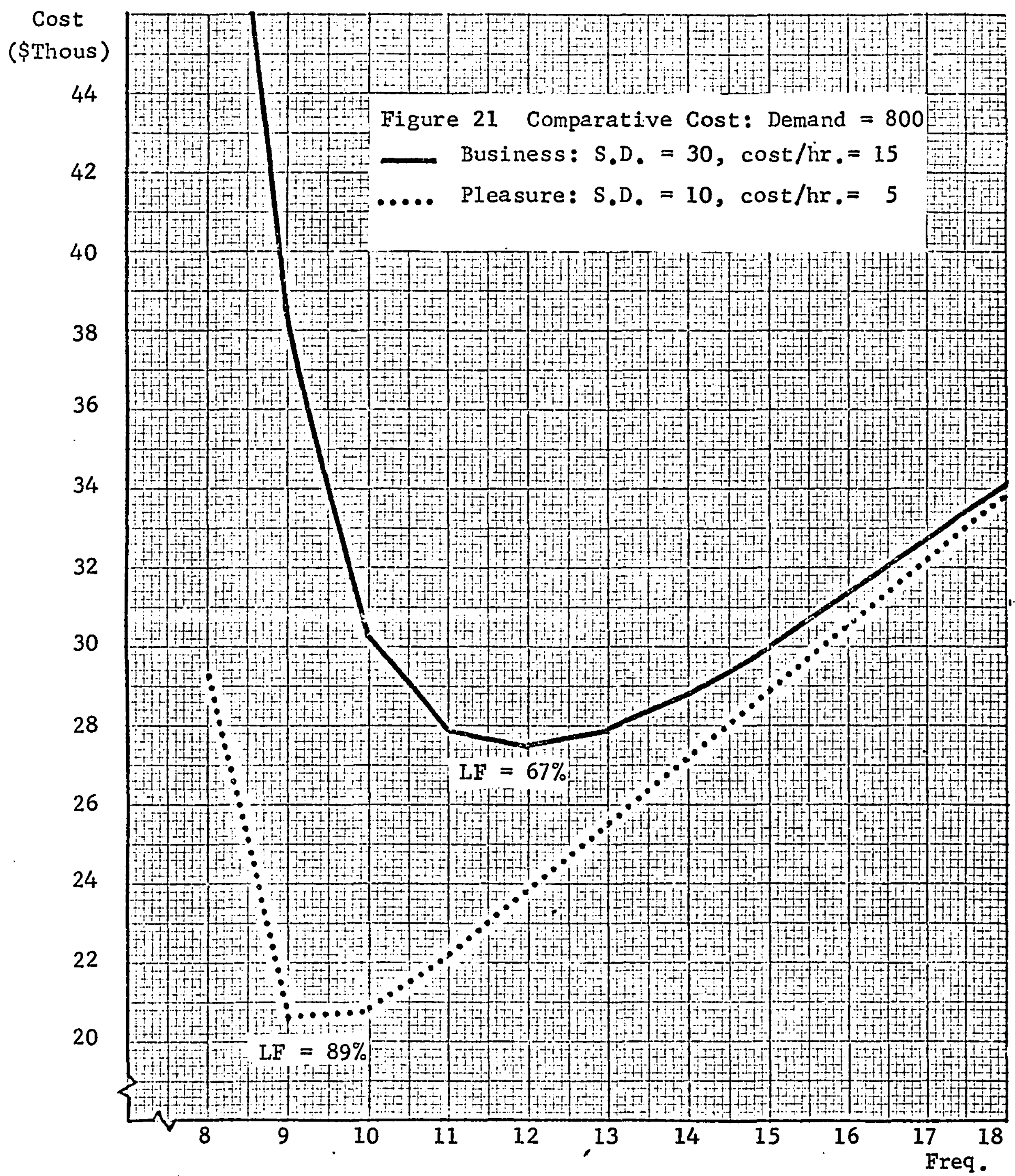


Figure 20

Total Cost vs. Frequencies Offered
Variable Dispersion of Demand

Demand = 800
C = 10
S.D. = 10 to 30


Cost
($Thous)
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22
20
Figure 21 Comparative Cost: Demand = 800
Business: S.D. = 30, cost/hr.= 15
Pleasure: S.D. = 10, cost/hr.= 5
LF = 67%
LF = 89%
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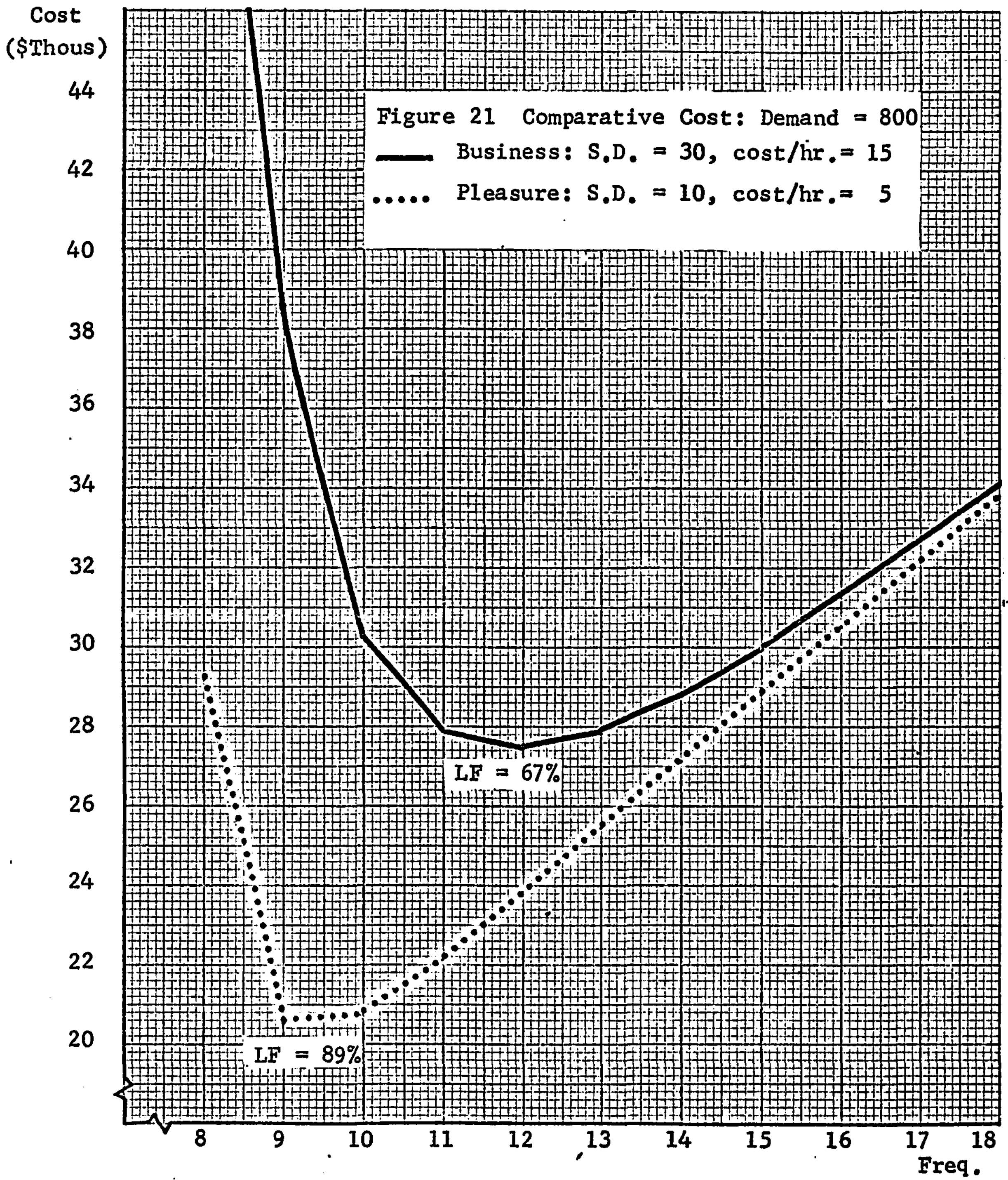
14
15
16
17
18
Freq.



Cost
($Thous)
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Figure 21 Comparative Cost: Demand = 800
Business: S.D. = 30, cost/hr.= 15
Pleasure: S.D. = 10, cost/hr.= 5
LF = 67%
LF = 89%
8
9
10
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17
18
Freq.

between total costs and the number of frequencies operated. As an alternative approach, we can change the axes so they relate to total cost and N, the number of passengers carried (figure 22). The number of frequencies is constant. As the number of passengers using the flights increases, the total cost goes up, with the rate of increase in cost dependent on the value of time lost and the dispersion of demand.

The form of this chart allows us to consider revenue on it. The form of the revenue line is difficult to specify because even in its simplest form it contains elements of passenger reaction to both price, p, and schedule, F, so it could be of the following form:

$$N = ap^{-b} F^{c} + d$$

Hence, total revenue would be specified as:

$$R = N\left(\frac{aF^{c}}{N-d}\right)^{1/b}$$

With cost and revenue functions defined for a fixed schedule of frequencies, F, a profit maximizing production level could be found.[5] This is, of course, true for each different traffic type, so that all price/output points can be determined.

C. INTERPRETATION

A number of implications related to the production and pricing of

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[5]The cost function is difficult to differentiate, but the marginal revenue function can be determined:

$$\frac{dR}{dN} = aF^{c} (N - d)^{-(1+b)/b} \left[N(b-1) - db\right]$$

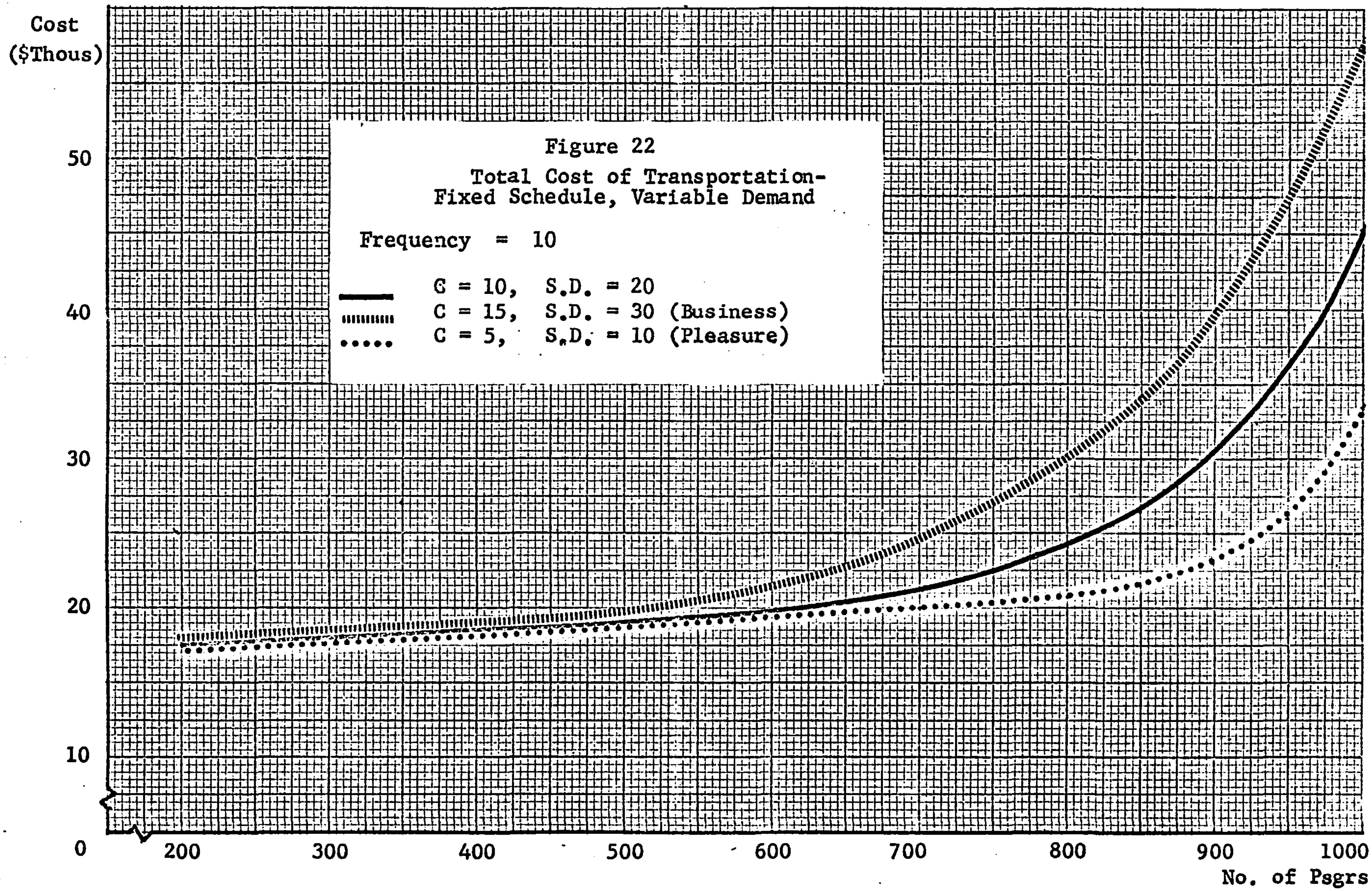

Figure 22
Total Cost of Transportation-
Fixed Schedule, Variable Demand

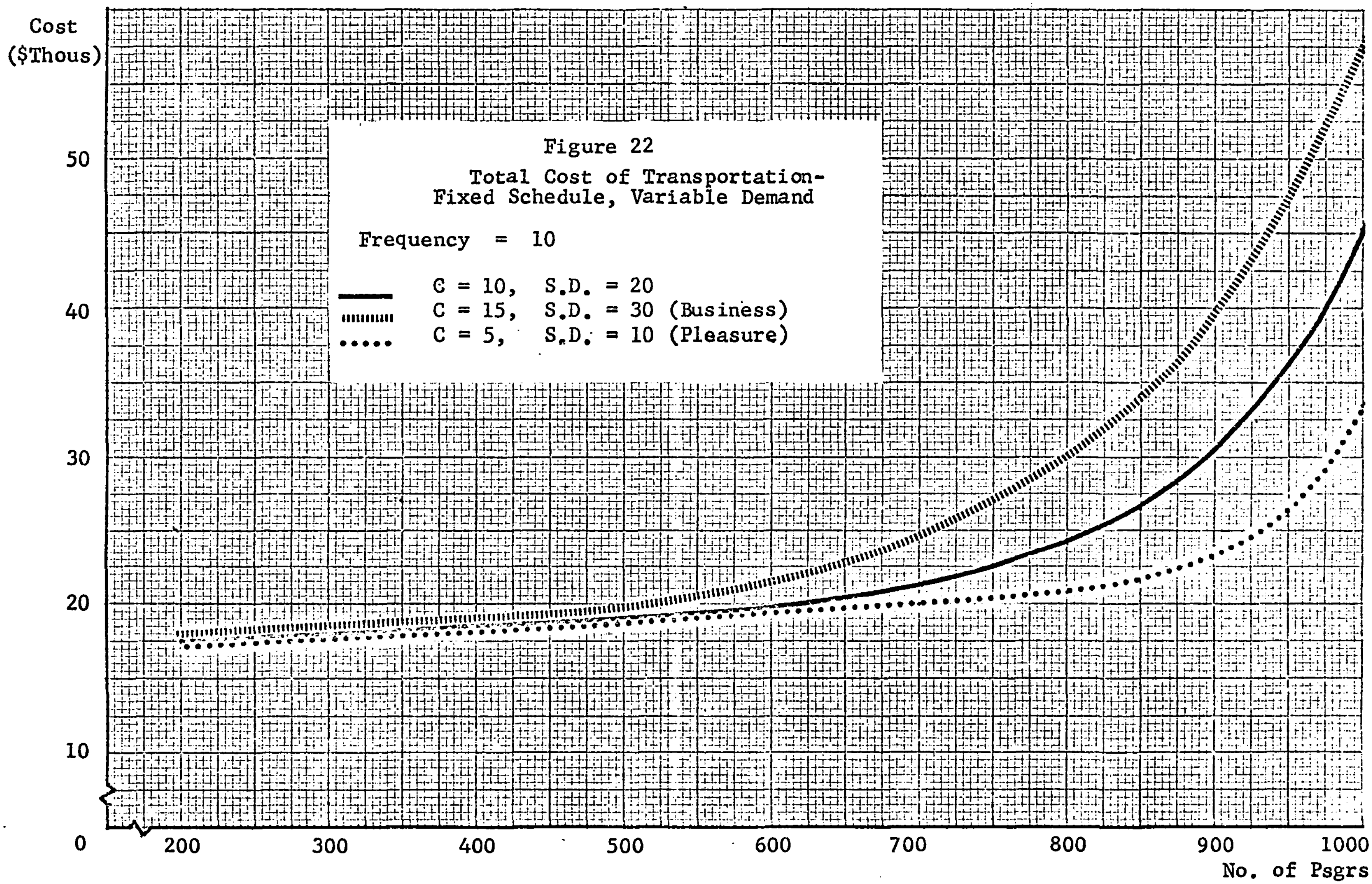

Figure 22

Total Cost of Transportation-
Fixed Schedule, Variable Demand

air transportation can be drawn from the behaviour of this function.

The first point, a reinforcement of something which has already been mentioned, is that it is difficult to define the nature of production in most transportation schemes. Even where the discussion is restricted, as it was here, to exclude the many measures not strictly related to traffic on a specific route, we are left with at least two: the number of trips or frequencies produced by the firm, and the number of passengers using the service. Our attention has centered on the number of different cost levels which can be associated with carrying the same number of people. There is another dimension as well which is concerned with the various costs and numbers of passengers carried with a given number of frequencies. The same schedule can be used in a wide variety of ways depending on the people who propose to use it. The supply function, representing the output of the airline, defines a range of possible consumption levels. In some sense, this makes the equilibrium level of supply and demand indeterminate because no single point is defined by the intersection.

It is difficult to redefine the consumption unit so that it is the same as the production unit except through a process of averaging - for instance, making a passenger equal to 1/60th of a frequency on the average. Once the units are equated, it is possible to go ahead and decide what level of output will satisfy the expected demand and what price should be charged. Because of the different consumers using the service, different levels of price and output will equate supply and demand, depending on who the passengers are, and what the nature of their demand is.

This suggests the next conclusion that can be drawn from the analysis. There is a significant difference in the nature of the product desired by different types of consumers. It is reasonable to assume that these different groups will pay different prices for what (to the airline at least) appears to be the same unit of output. If prices are purely cost based, the price for vacation would be set below the charge for business travel. However, the implications for a profit maximizing firm are not so clear - the result is dependent on the parameters in the demand function itself.

In order to consider the factors mentioned here in a real pricing situation, administrative feasibility becomes important. One fairly simple approximation of the process would be a fare system which provided for different fares depending on the lead time between the reservation and the trip. This might help the airline in planning its output. Passengers who made the decision to travel early would be offered a lower fare than those requiring short term availability on seats. The price might reach a peak six to twelve hours before flight departure, after which it would decline again finally becoming a "stand-by" fare at the departure time.

Another potential scheme which might exist independently of or be combined with fares based on reservation lead time could involve direct determination of the passenger's travel plan flexibility. If the trip was such that it could be made on any one of three or four days or at three or four different departure hours, the airline could take advantage of the passengers' adaptability and combine them in such a way as to maximize the load factor achieved. Increased flexibility would be rewarded by a lower fare. The passenger requiring a specific flight would be charged a higher price. Under a combined system, the passenger who booked early and was flexible in the timing of his trip would receive the lowest price.

V CONCLUSION

Pricing efforts in the air transportation industry have had to face the same difficulties as have been present for all transportation companies in the past. The most obvious conclusion would seem to be that the firms have not paid sufficient attention to cost and demand conditions and the relationship between them. But this would be a considerable simplification of the problem which actually faces the transportation firm, because it does not recognize the questions which must be answered before a suitable price can be determined.

Basically, the questions center around what the unit of transportation output is. In most economic analysis this is not a problem - what the firms produce and the consumers purchase is the same product and the economist can present diagrams and equations for price determination using the same quantity units for both. Our discussion of the relevant cost function for air transportation, even with the assumption of known demand, was made difficult by the divergence between the aircraft frequencies which make up the schedule and the individual seats which are sold to the consumer. The implication of this disparity is that marginal cost pricing on an individual seat basis is not applicable and average costs are much more relevant in this context.

The operating cost at any specific point in time is a complex function which involves a great deal of interaction among all the routes in the system and the demands placed upon them. The price determination process is equally complex. Profit maximizing behaviour would require a tremendous amount of knowledge about the demand conditions on individual routes at each moment in time - information which is not available to any airline. Other pricing policies which require less market information, such as cost-based prices, will be easier to apply and more likely to be internally consistent,[1] but they are unlikely to be optimal in any sense and may not even be feasible.

In addition to these difficulties introduced by market interrelationships, the firm must be aware of the uncertainties of demand and make some allowance for it in price and output planning. The level of service experienced by the consumer, which includes things like flight availability, is an important part of the product as it is perceived in the market place. A major task which the airline faces is determining what supply should be offered to meet this uncertain demand. Some concept of disutility cost is of assistance

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[1]Consistency in fare structure requires that longer trips generally be more expensive than shorter trips and, in all cases, that the fare between any two points be equal to or less than the sum of the fares over any intermediate routing. For example, the fare between Montreal and Vancouver cannot be greater than the sum of the fares from Montreal to Winnipeg and Winnipeg to Vancouver. Profit maximizing behaviour based on individual market demand conditions may result in violations of this condition.

here. This cost represents the passenger disutility resulting from congestion in the system. It is dependent not only on the overall demand level in relation to the schedule but also on the dispersion of this demand and the opportunity cost of time lost by passengers because they are unable to travel at the time they desire. Because different passengers have varying dispersions of demand and place unequal value on time lost, the service cost will vary depending on the nature of the demand. A comparison of business and pleasure travellers indicates that the difference in the utility they place on a choice of flight implies that the production/consumption relationship will be different for the different passenger types. Because of their relative flexibility in trip planning, a given number of tourists can be accommodated at lower total cost and with less capacity than an equal number of business-type travellers.

This variation should be recognized and incorporated into the price structure. The question which remains is how this can be done in the most feasible manner from an administrative point of view. Two basic approaches may be considered - the first, a price based on the time between date on which the reservation is made and the trip time; and second, a price based explicitly on the passengers' stated travel time flexibility.

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