PARTS OF THE AIR CARGO MARKET:

PRICES AND LOAD FACTORS

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ABSTRACT

In the deregulated air cargo industry, carriers are able to adjust not only schedules and services offered, but also prices. In so doing, they must be aware not only of competition from other air carriers and other modes of transport (e.g. trucking), but also of competition between subdivisions of the air cargo industry which may be represented within the same company: for instance, competition between all-cargo flights and the freight compartments of passenger planes for the carriage of freight. A computer simulation of shipper response to changes in price and other conditions, which allows comparison of multiple market segments, is given. Illustrative runs suggest rather strikingly that all-cargo service at full rates and service in passenger planes at reduced rates are not in direct competition.

INTRODUCTION

While the airline industry has been studied extensively, most of the work has concerned passenger operations. Serious efforts have been made to model operating costs and demand (5), carrier adjustments of capacity (4), and other aspects of the passenger market. Recently, there has been increased interest in the air freight industry. The CAB itself commissioned a detailed study of operating costs (2) in all-freight service; some attempts to model the demand side of the air cargo market are discussed in (3).

The air cargo market is now changing rapidly, as the recent deregulation leads to at least two classes of activity: (1) carriers vary prices and services to try to find how responsive demand is, and (2) carriers try to seize larger market shares, in accordance with the established principle in the industry that it is cheaper to buy market share early in the development of the market.

During the period of CAB regulation, prices were heavily regulated. In particular, prices for carrying freight in passenger plane bellies were tied to the operating costs of all-cargo flights. As a result of this, there is very little information now publicly available on responsiveness of demand to price or on responsiveness of demand to price competition between all-cargo flights and carriage of freight in passenger bellies. Thus, many of the numbers needed to forecast future industry trends are unavailable. It is the intent of this paper (1) to briefly discuss the structure of the air cargo industry, with a view to identifying some of the most important parameters; (2) to provide a simple method of simulating on a computer the division of demand between market segments; and (3) to illustrate use of the simulation by discussing results for some estimated values of the main parameters.

DEMAND FOR AIR CARGO SERVICE

Air shipment of freight is basically a luxury service. Fuel economics alone require that air freight must be considerably more expensive per ton-mile than shipping by truck. In most cases, the only thing justifying shipping by air is time saved. Of course, shipping by air is not always faster than by truck: over distances up to a few hundred miles, and with shipment sizes that permit door-to-door service by truck, the necessity to repack between plane and truck at two airports may make air travel slower.

Shippers often prefer to have a package leave their loading dock in the late afternoon and arrive at the consignee's loading dock early in the morning. Allowing for pick-up and delivery schedules and traffic congestion around airports, this may require travel on flights leaving after 9 p.m. and arriving before 5 a.m. Unfortunately, these are the hours with the least passenger traffic--when small freight shipments cannot routinely be placed in the belly of the next scheduled passenger plane. This is one factor giving rise to the phenomenon of nighttime all-freight service and the willingness of some businesses to pay premium prices for such service.

SUPPLY CONSIDERATIONS AND PRICE REGULATION

Packages of small enough size can be placed in the freight compartment (belly) of a passenger plane; larger objects or containers cannot fit there. The economics of aircraft manufacture dictate that most large aircraft for carrying freight (except for some military applications) are built on the same general pattern as passenger aircraft: a cylindrical body with a non-removable main deck just below halfway up the fuselage (it is placed so as to maximize hip room for seats placed on it). Thus in passenger planes, a fixed portion of the plane volume is set aside for baggage and freight; in an all-cargo plane, the same bottom compartment is available for small packages while the top deck becomes available for larger packages or containers. The volume/weight lifting ability of the plane is strongly influenced by the use for carrying passengers; thus the freight compartment on a passenger flight will most likely fill by volume rather than by weight, while all-cargo flights are more likely to fill by weight rather than by volume.

Prior to the deregulation of the airline industry now in progress, the provision of extra capacity in a given city-pair market was the principal competitive tool open to passenger carriers; see (4). This led to an increase in available space in passenger plane bellies at a time when the CAB would not permit prices for belly cargo to be systematically reduced. Thus, during years when passenger planes were averaging 55 percent load factors, the belly space in the same planes was experiencing load factors below 25 percent. The CAB rejected the argument that the expenses of the flight were largely met by the passengers and that belly freight could be priced based on its marginal cost; belly freight was required to bear "its share" of all costs, and priced essentially as if it were on an all-cargo flight.

With the deregulation of freight pricing, the carriers are at liberty to charge differently for freight carried in all-cargo service and freight carried in passenger flights. In making such a decision, a carrier might take into account some of the following factors:

(1) Night freight travel is more desirable for some shippers.
(2) If the same rates are charged for the day (passenger belly) and night (all-cargo) service, the load factors experienced in the day service will be unreasonably low.
(3) If day rates are set too low, they may draw business from the night service. Since the freight is the only business on the night all-cargo flights, reduced business there will cause it to operate at a loss or be discontinued.
(4) In view of the preference of shippers for dealing with one supplier for multiple shipments, some day business may be lost to competitors if no night service is provided.

It is worth noting that there are other factors at work in determining the mix of services and prices offered. For instance, the recent fuel shortage has caused carriers to reduce the number of flights made in some areas. A number of airlines, both in the U.S. and overseas, have elected to cancel all-cargo flights to save the fuel for passenger flights, confirming the widely held view that the combination carriers view freight carriage as a minor appendage to passenger operations (6).

IDENTIFYING VARIABLES FOR MODELING

In the classical model of supply and demand -- the model that might apply to a company operating in a single market segment -- the supplier is assumed to maximize profit by adjusting prices, causing volume to change, to maximize the excess of volume times price over cost. Obviously, the situation faced by an airline offering passenger and cargo service is very different. Maximizing profit on freight carried in passenger bellies may compete with night all-cargo service (by the same carrier) to such an extent that that becomes a losing operation. On the other hand, maximizing night volume may mean there is little day freight volume--causing the freight compartments of passenger planes, which must travel anyway, to be empty. Thus one must try to maximize profit as a function of at least two variables, the day freight rate and the night freight rate, where supply options (and marginal costs of carriage) are substantially different in the two cases.

These two are not, of course, the only variables. Frequency and speed of service are difficult-to-measure variables of great importance. Also, one may vary prices by size or density of cargo (among other variables). Another example: Large objects, or large containers, can be carried only above the deck, thus only on an all-cargo plane. Smaller packages can be carried either above the deck, or below the deck in a passenger or an all-cargo plane. Prices must be set to avoid having an excessive percentage of the large containers or packages in the mix of cargo shipped.

Can this rather large list of potential variables be coped with without a large and cumbersome model? The simulation discussed here is a very simple one -- very undemanding of computer resources -- simple enough to be used in elementary instruction in management or operations research, yet able to consider a rather large variety of variables. It is designed to allow one to describe demand for freight carriage by a probability distribution covering several variables, and see how it will distribute itself among various market segments. That is, given adequate input data, it could determine such things as in what price range day freight (passenger bellies) will compete with other carriers (e.g. trucks) and in what price range it will compete with night all-cargo carriage.

STRUCTURE OF THE PROGRAM

In the particular model runs used here, we have described a shipment by four attributes:

(1) The maximum time allowable for the shipment to reach its destination (to allow representing "urgent" shipments).
(2) The cost per hour to the shipper of having the article in transit (a proxy for inventory costs, goodwill, etc.).
(3) The distance the shipment is to travel.
(4) The time of day when the shipment is ready to leave the shipper's loading dock.

We have described each of the possible modes of shipping by providing these attributes:

(1) Fixed cost, a price per shipment (to cover paperwork, loading, local delivery, etc.).
(2) Variable cost, a linear function of distance.
(3) Fixed time delay dependent on mode of shipment (loading, etc.).
(4) Time delay variable by time of day the shipment is ready to leave (traffic delay, availability of flights, . .).
(5) Time elapsed due to distance travelled.

The reader will see that several important variables have been omitted; for instance, shipment density, and the size of the shipment either as to whether it is a truckload lot (which would tend to reduce cost per pound and increase handling priority if space were available) or whether it is physically large items (which would make passenger belly shipment unavailable). The intent has been to keep the model simple enough to be run easily while including a sufficient variety of variables to see how they are used and make it easy to add other variables later.

The computer implementation of the simulation is written in CBASIC, a dialect of BASIC in wide use on 8080-based microcomputers; the program is about 75 lines long, hence readily adaptable. After reading the parameters describing the various market segments and the numbers used to determine the mix of shipments to be used, the program follows a simple algorithm:

(1) Generate a shipment, assigning values to its (four) parameters using a variety of counters and random number generators.
(2) For each of the market segments (potential carriers) included, compute

the shipping charge and the perceived cost to the shipper (which includes the shipping cost as well as cost of time-in-transit).

(3) Among the shipping means meeting the time limit, find the one perceived as least costly by the shipper. Add the shipment to the totals for that means of transport. For each rejected shipping means, record if it was rejected due to the time constraint or due to high price.

(4) If enough shipments have been considered, print totals. Otherwise, return to step (1) above.

Running this simulation several times, varying prices for a particular segment, will show which other segments that segment competes against in various price ranges. Similarly, varying time-of-day delays or fixed delays would tend to show the competitive effects of improved service.

ILLUSTRATIVE RESULTS

Since real-world data is relatively difficult to obtain, test runs were made with artificial data intended not to be too unrepresentative of real situations. Even with the artificial data, some quite striking results were obtained.

For all runs we assumed homogeneous shipments (i.e. all shipments of like weight and volume) and estimated charges that would apply to medium density shipments of weight approximating 500 kilograms. Prices cited are intended to represent about 50 kg (100 lb.) units. A standard unit of distance was also used, taken as about 320 km (200 miles). Three modes of transportation were considered: "truck", a proxy for land transport; "belly freight", a proxy for space-available or standby air freight subject to 5-to-10 hour delays before takeoff, and "all-cargo", a proxy for fast air freight travelling on schedules convenient to the shipper. It was assumed that travel by any mode took a base time of 4 hours (for loading/unloading/delivery) plus 1 hour per unit of distance by plane and 4 hours per unit of distance by truck; that belly freight encountered delays of 0 hours, 5 hours, or 10 hours with equal probability. "All-cargo" freight was subject to delays of 0, 2, or 3 hours when belly freight suffered 10, 5, or 0 hour delays.

The first run was intended to determine the effects on choice of mode of the perceived value of time to the shipper. It was assumed that shipments cost (in dollars, where D is the distance to travel in units):

TRUCK: 3 + 1D   BELLY FREIGHT: 6 + 2D   ALL-CARGO: 12 + 5D

It was also assumed that each shipment must reach its destination within a deadline (these were chosen randomly and varied from 4 to 64 hours) or it would not be shipped; and that the shipper assigned delay in shipment a value varying from X to 10X dollars per hour, with X the experimental variable. That is, with X = .1, the value of time was \$.10 to \$1.00 per hour; with X of .5 it was \$.50 to \$5.00 per hour. The table below shows the percent of shipments going by each mode for several values of X.

METHOD	PERCENT SHIPPED THIS WAY WHEN X IS			MEAN REVENUE PER SHIPMENT WHEN X IS		
	.1	.2	.5	.1	.2	.5
TRUCK	53%	35%	21%	\$ 7	\$ 6	\$ 5
BELLY FREIGHT	35	53	54	20	19	19
ALL-CARGO	7	7	20	44	44	41

The percentages total 95 since 5 percent of potential shipments are not made; no adequately fast means is available. The mean revenue figures show that as the value of time rises, fast methods are used to send things shorter distances but that this does not dramatically effect average distances for the air modes. The more interesting observation is that for "low" values of time, belly freight competes primarily with trucking; for "high" values, belly freight market share remains stable and all-cargo service gains. In the X = .1 and X = .2 columns, all-cargo (expedited) air service is used only when it is the only means to meet the deadline; once X = .5, two-thirds of its customers are using it to reduce perceived cost rather than meet a deadline. (Table based on 1500 shipments).

In the next table, we consider competitive effects of rate reductions for the air modes. Setting the perceived value of time in the $.10 - $1.00 range (X = .1 above) and keeping truck rates as above -- that is, 3 + D dollars where D is the distance to be travelled, we obtain the following percentage distribution of mode of shipment:

METHOD	WHEN THE COST OF EACH METHOD IS				
BELLY FREIGHT	6 + 2D	6 + 2D	6 + 2D	5 + 1D	5 + 1D
ALL-CARGO	12 + 5D	9 + 3D	6 + 2D	12 + 5D	6 + 2D
METHOD	**THEN THE PERCENT OF MARKET IS**				
TRUCK	53	53	42	30	27
BELLY FREIGHT	35	35	20	58	59
ALL-CARGO	7	7	32	7	9

Again, the 7 percent figures for all-cargo are the shipments that cannot reach their consignee on time by any other means. Note that when all-cargo prices are cut, it makes little difference until it approaches the price of belly cargo service; even when they have equal prices, a considerable percentage still goes belly cargo simply since the next available flight is of that type (the 20/32 percent division is not significant in this simulation). The interesting column is the fourth; here a reduction in belly cargo prices has drawn significant business away from trucking without any effect on all-cargo traffic. Unfortunately, the price cut is so extreme that total revenue from belly freight falls (from about $704 aggregate per 100 shipments total to about $701 aggregate). (Table based on 1200 additional shipments).

These illustrative runs of the model are not intended to produce precise quantitative results. On the other hand, the qualitative results produced are quite striking: that with price ratios similar to those presently in effect, all-cargo service attracts only shipments on very tight deadlines or where the value of time is considered very high by the shipper, while belly freight competes primarily on a price basis with trucking. These observations seem to agree with the dominant phrasing of recent air freight advertising: compare (7) and (8). Further, they suggest strongly that appropriate price adjustments could attract significant belly cargo (or "standby" air cargo), increasing the load factor for passenger plane freight compartments, without significantly hurting revenue from expedited freight/all-cargo service.

CONCLUSION

A very simple simulation of the way demand distributes itself among market segments is possible. Requiring a minimum of programming effort and computer resources, it gives promise of helping to determine whether particular changes in the price or level of service provided by one segment of the air cargo industry will compete primarily with another segment of the air cargo industry or with some other mode of carriage. Thus, it provides a means for determining the range in which prices and load factors in the passenger belly freight market may be adjusted without making the offering of all-cargo service by the combination carriers uneconomic. Further, it shows a way in which estimates of price sensitivity, perceived cost of time-in-transit, and arrival deadlines on the part of shippers may be used by air carriers in devising price and schedule strategies. While good estimates of many of those parameters were not available during the days of rate regulation, present price variation and extensive price-and-schedule advertising by the air carriers seems to be intended to make estimates of these parameters available in the near future.

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