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THE POTENTIAL FOR AIR SHIPMENT OF ARIZONA HORTICULTURAL PRODUCTS

by

H. Benjamin Hunter

A Thesis Submitted to the Faculty of the

DEPARTMENT OF AGRICULTURAL ECONOMICS

In Partial Fulfillment of the Requirements
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ABSTRACT

The fruit and vegetable industries of Arizona are an important part of the local economy and could play an increasingly important part in the future. These industries are characterized by large shippers and growers who operate in fairly concentrated areas. The principal crops of interest to Arizona are lettuce, cantaloupes, and citrus fruits. Lettuce is the main interest at the present and receives the most attention in the analysis.

The costs of shipping lettuce or other products depends on the relative costs of transportation by mode and on related costs such as the costs of damages or time. Air transportation costs are quite high at the present, but there is a prospect for as much as a 30 per cent reduction in present costs due to the advent of large jets like the Boeing 747.

Shipping fruits and vegetables by air at the present does not seem likely due to the large differential in costs between air shipped produce and rail or truck shipped produce. If air shipping costs were lowered 30 per cent there would still be a differential in costs of shipping by the air mode versus the surface modes. The feasibility of shipping by air would depend upon the consumers' willingness to pay the needed premiums for air

shipped products. Other new technology within the perishables marketing system could also alter the shippers' decisions of what mode to use.

CHAPTER I

INTRODUCTION

The changes in technology over the last decade and the technology due to appear in the 1970's has created widespread interest in air transport. The changes in world markets have also caused increased interest in air marketing. The European and Scandanavian countries and Japan have a good basis for a winter export market from the United States. The eastern cities in the United States are also large winter markets for fresh produce. Air transported produce will be able to reach virtually anywhere in the world in twenty-four hours. The consumer has an important bearing on the quality of goods marketed and the type of transportation which prevails. The consumers in turn are becoming more aware of the quality and freshness of their products.

This interest in the potential for air shipment of Arizona horticultural products was brought to a focus in a state research project in the Department of Agricultural Economics of The University of Arizona. A justification for this research is that an evaluation of the potentials for air transport of Arizona horticultural products would assist the air transport industry in adjusting to Arizona's needs which in turn would benefit Arizona horticultural producers through better service and lower prices for the service. A further justification would be the importance of a winter export market to the Arizona economy in the years ahead. The declining demand for cotton makes vegetable crops an increasingly attractive alternative crop for many Arizona farms. The climate in Arizona is well suited to growing the spring, winter, and fall vegetable crops. While potential for expansion of the United States market for these crops appears very limited, the European and Japanese markets seem to offer potentials for vast expansion. A highly developed export market for Arizona using air and sea transport would help reduce the high dependence on cotton as a major source of income and would reduce the effects of an unfavorable cotton market upon the Arizona economy.

The products that seem to be the best candidates for air shipments are products which are perishable and the high value-density products. Cut flowers have moved by air because of their high value-density and highly perishable nature. In California there are air shipments of strawberries on a significant volume basis. These strawberries may go to markets in Germany, Holland, Sweden, and other European countries. By using cargo jets, the transit time is reduced to around thirty-six hours for moving the strawberries from the field to the European consumer market. Iceberg lettuce seems to be the next most likely candidate for air shipment. Iceberg lettuce is quite perishable and has a high value-density for an agricultural commodity. The demand for this product is well established and world wide in scope. Melons are another candidate; however, they rank lower than lettuce because their value density is lower. Citrus crops have been considered also, even though storage of the citrus products is less of a problem than for the more perishable products.

Throughout the thesis, the examples and discussion are concentrated on the iceberg lettuce market because lettuce is the largest cash horticultural crop for Arizona. This increases its importance upon the economy.

Arizona Fruit and Vegetable Production and Marketing

The size and concentration of the fruit and vegetable industry of Arizona are factors that will affect the growth potential of air transport of Arizona horticultural products. Some fruit and vegetable crops grown in Arizona are either too small in volume or not so highly perishable as to suggest much immediate prospect for air transportation.

Iceberg lettuce is the largest of the vegetable industries in Arizona in terms of cash receipts and cantaloupe is second. Arizona ranks second only to

California in total lettuce grown and shipped in the United States. The 1962-1966 average Arizona cash receipts for lettuce were 49 million dollars at the farm level (Cooperative Extension Service and Agricultural Experiment Station [C.E.S. and A.E.S.], 1968, p. 20). Cantaloupes were the next largest vegetable crop with an average value of nearly 15 million dollars (C.E.S. and A.E.S., 1968, p. 20). Lettuce is one of the most perishable crops grown in Arizona, which makes this crop a good candidate for air transport.

Table 1 shows Arizona's share of various vegetable crops in the United States for 1967 and 1968 seasons. Vegetables accounted for 16.8 per cent of the total cash receipts in Arizona in 1967 (Arizona Crop and Livestock Reporting Service, 1969, p. 7). As a state, Arizona ranked fourth in the United States in harvested acreage, production, and value of fresh market vegetables and melons in 1968 (Arizona Crop and Livestock Reporting Service, 1969, p. 26).

Table 2 gives the acreage, production, and value of Arizona vegetable crops as a per cent of the total U. S. acreage, production, and value of vegetable crops. This was done using the data given for U. S. and Arizona vegetable crops from Table 1. In Table 2, in all but two cases Arizona's production was a greater per cent of the United States total than was acreage of the same crop, and

Table 1. U. S. and Arizona Vegetable Crops: Acreage, Production, and Value for 1967 and 1968

		Acres Harvested		Production (000) ctw.		Value (000) dollars	
		1967	1968	1967	1968	1967	1968
Spring Cantaloupes	Arizona	10,900	11,600	1,308	1,392	12,688	11,275
	U. S.	33,800	38,200	3,885	3,841	34,440	27,516
Early Summer Cantaloupes	Arizona	1,100	1,000	82	120	713	840
	U. S.	13,500	13,400	751	806	4,293	4,111
Early Fall Cantaloupes	Arizona	450	500	54	60	346	432
	U. S.	3,250	3,300	460	382	2,234	2,171
Early Summer Honeydews	Arizona	1,300	750	117	79	983	624
	U. S.	1,300	750	117	79	983	624
Winter Lettuce	Arizona	16,000	14,000	2,800	2,660	10,500	14,364
	U. S.	75,800	70,200	13,005	12,240	47,287	58,181
Early Spring Lettuce	Arizona	17,100	17,800	3,420	3,115	25,992	15,419
	U. S.	41,200	46,000	7,788	9,560	48,553	34,605
Late Fall Lettuce	Arizona	14,100	13,600	2,326	2,176	12,793	12,838
	U. S.	14,100	13,600	2,326	2,176	12,793	12,838
Early Summer Watermelons	Arizona	3,400	4,000	595	680	1,993	2,074
	U. S.	188,700	201,100	14,712	16,195	31,461	26,015

Source: Arizona Crop and Livestock Reporting Service (1969, p. 8).

Table 2. Arizona Vegetable Crops: Acreage, Production, and Value as a Per Cent of the Total U. S. Acreage, Production, and Value

	Acres		Production		Value	
	1967	1968	1967	1968	1967	1968
Spring Cantaloupe	32.3	30.4	33.7	36.2	36.8	41.0
Early Summer Cantaloupe	8.2	7.5	10.9	14.9	16.6	20.4
Early Fall Cantaloupe	13.9	15.2	11.7	15.7	15.5	19.9
Early Summer Honeydews	100.0	100.0	100.0	100.0	100.0	100.0
Winter Lettuce	21.1	19.9	21.5	21.7	22.2	24.7
Early Spring Lettuce	41.5	38.7	43.9	32.6	53.5	44.6
Late Fall Lettuce	100.0	100.0	100.0	100.0	100.0	100.0
Early Summer Watermelons	1.8	2.0	3.8	4.2	6.3	8.0

Source: Table 1.

Arizona's value was a greater percentage of the United States total than was production of the same crop in all cases. It can be concluded that Arizona's yields of the crops in Table 1 were better than average, and that Arizona's prices were greater than the average of all states.

Fruit production and values in Arizona are compared in Table 3 for 1966 and 1967. Arizona shares about one-fifth of the total market for lemons in the United States. Oranges are the largest cash value citrus crop in Arizona, but the state grows only five per cent of the total United States crop. Fruits comprised 11.8 per cent of Arizona's cash receipts for farm and ranch products in 1967, with a total value of 28.3 million dollars (Arizona Crop and Livestock Reporting Service, 1969, pp. 6-7). Citrus production is concentrated in two areas--the Salt River Valley in Maricopa County and the Yuma district in western Arizona. Most shipping is done on a large scale through the large packing plants and is influenced by large marketing cooperatives.

Lettuce is a highly perishable crop compared to other fresh crops in Arizona. Lettuce cannot be stored for more than a short period, and freshness of lettuce at the retail level is highly dependent upon the marketing process. Many crops can be harvested before they are fully mature or ripe at harvest time. Melons or citrus may be

Table 3. Citrus and Grape Production and Value for Arizona and the U. S., and the Per Cent of Total That was Produced in Arizona

	Production				Value			
	1966	%	1967	%	1966	%	1967	%
	(000)		(000)		(000)		(000)	
Oranges (ctns)								
Arizona	7,820	2.1	6,240	2.5	9,421	2.8	14,685	3.8
U. S.	367,220		249,640		337,506		382,542	
Grapefruit (ctns)								
Arizona	3,360	3.0	7,480	8.5	2,604	3.4	6,844	6.6
U. S.	111,760		88,120		76,559		103,323	
Lemons (ctns)								
Arizona	5,620	15.7	6,500	19.6	8,402	14.3	11,081	16.6
U. S.	35,820		33,100		58,685		66,502	
Tangerines (ctns)								
Arizona	540	2.5	405	3.5	1,036	8.3	633	3.9
U. S.	21,200		11,545		12,512		16,391	
Grapes (tons)								
Arizona		.3		.3	3,276	1.6	5,377	2.5
U. S.	3,734		3,069		207,038		212,311	

Source: Arizona Crop and Livestock Reporting Service (1969, p. 8).

harvested at full maturity for the local market and at less than full maturity for storage purposes or to reach distant markets.

There are several reasons immediately obvious as to the attention lettuce has received in the air cargo picture. First is the high value and rapid deterioration characteristics of lettuce. Also important is the size of the lettuce industry which makes the cargo carriers more interested due to the prospect of large volume. Another reason is that there are some very progressive people in the management of the lettuce shipping industry.

The Concentration of the Vegetable Industry in Arizona

The concentration of the vegetable industry in Arizona is interesting. Lettuce production and shipping is concentrated primarily in the Yuma area, Maricopa County, and Pinal County. The winter lettuce crop is based in the Yuma area where eight shippers each ship lettuce from over 1,000 acres (Arizona Fruit and Vegetable Standardization Service, 1969).[1] The early spring lettuce crop is concentrated in Maricopa and Pinal counties. The Salt River Valley area around Phoenix produced 6,931 acres

1. All the data cited for production and shipments and concentrations of lettuce and cantaloupe crops are from the source (Arizona Fruit and Vegetable Standardization Service, 1969) cited above.

of lettuce during the 1968-69 season. In this area there were 12 shippers that handled 64 per cent of the total acreage of lettuce. In the Harquahala area 7 shippers handled 1,620 acres of lettuce. In the Marana-Redrock-Eloy-Maricopa area 7,251 acres were harvested in the 1968-69 season, and 9 shippers handled 80 per cent of the volume. In the Wilcox area there were 3,860 acres of lettuce in the 1968-69 season, and 7 shippers handled over 3,000 acres of the total.

The late fall Arizona lettuce crop is concentrated in Maricopa, Pinal, and Cochise Counties, with a small amount in Pima County. For the 1968 season the Salt River Valley area had 6,950 acres of lettuce with total shipments of 2,691,217 cartons of lettuce. Ten shippers in this area accounted for 60 per cent of the volume. In the Harquahala area there were 5 shippers for 995 acres of lettuce. In the Marana-Redrock-Eloy-Maricopa area there was a total of 4,131 acres of lettuce with 1,223,348 cartons shipped and 8 shippers handled 82 per cent of the acreage. In the Wilcox area there were 8 shippers and a total of 1,280 acres of lettuce.

The Yuma cantaloupe crop in 1968-69 had a total of 10,154 acres with 1,513,255 crates shipped. There were 5 shippers who each handled over 1,000 acres. In the Parker-Poston area there were 4 shippers who handled a total of 1,937 acres and 341,092 crates of cantaloupes. In the Salt

River Valley 2 shippers moved 78 per cent of a crop of 1,052 acres.

The size and concentration of the major perishable crops industry in Arizona seem to be of a scale that would favor the air carriers. Size and concentration are important factors because of the effects they have on handling and shipping costs. It appears that the most efficient method of air shipping a product would be for the shipper to charter a plane and fly loads directly to buyers on his own timetable suited to his particular needs. There must be enough daily production in an area reasonably near the airport to make this method feasible. The cargo planes in operation today can carry 92,000 pounds of cargo, which is about twice that of a refrigerated truck van. In a small producing area where there are no existing airport facilities, the cost of moving the produce to the airplane for loading is increased. The load must be consolidated and then trucked to the airport for shipment. In an area as that around Phoenix, there is a large daily volume of lettuce moving during the shipping season, and large numbers of jet aircraft could be easily utilized to the full extent. Present day marketing patterns would have to be altered somewhat to utilize jet cargo movement. The buyers in the large city wholesale markets have historically done their trading in the early morning hours only, but these habits may change. Different patterns of trading would likely accompany any shift to air transport of fresh produce. It is possible that plane shipments would move directly to the retail buyer who would take delivery a few hours after the produce was harvested.

The Marketing Patterns of the Arizona Lettuce Industry

The marketing patterns of the Arizona lettuce industry is of importance to the problem. Some of the patterns are not well suited to the entry of air shipment. Lettuce is a field ripened product that is highly sensitive to handling after it is harvested. Presently, the practice is to pick lettuce and pack it into standard size cartons in the field. After picking, the lettuce is hauled by truck to the shipper's facilities where it is hydrocooled, a vacuum cooling process, down to an optimum temperature of 36-40 degrees Farenheit. After cooling, the lettuce is usually loaded on either truck or rail cars and shipping is begun. The shipment to New York City by truck may take seven or eight days. The truck vans and rail cars are refrigerated during transit by mechanical coolers which keep the lettuce at a low temperature to retard spoilage. The lettuce is picked up by the retailer at either the rail siding or it may be delivered to him by truck. In most cases, the lettuce reaching the retailer has had temperatures well maintained and therefore, is of good quality. With reasonable care and normal transit times, the lettuce should reach the retailer shelves on the seventh, eighth, or ninth morning after leaving the Arizona fields.

In order to ship lettuce by air, the shipper must make the transfer at the airport from the truck, and also the lettuce must be picked up at the final airport. This would entail extra costs due to the handling of lettuce at both airports. Lettuce is not cooled while in air transit, which may affect quality in some cases. The distance to the airport, the time spent in loading and in unloading, and the time spent waiting to land and take off are all of importance to the quality of the lettuce and the costs of shipping by air. If a plane is not chartered there may be considerable delays and tie-ups which increase costs and deterioration of the lettuce. Chartered flights are more timely in respect to availability at the proper times. One shipper who was interviewed in Salinas, California reported that one airline had arranged to fly three loads of lettuce but left one at the airport all night because the plane was already full. The shipper was dissatisfied and the airline had to pay for damage in transit. Chartering of planes would help eliminate such needless waste and keep the unit costs of shipping the product as low as possible.

Most important in the present analysis is the fact that no significant volume of lettuce is air shipped. Almost all of the out-of-state shipments are truck or rail shipments. All of the domestic air shipments of lettuce so far could be characterized as experimental. Other Arizona crops such as cantaloupes, citrus, and grapes do not move in significant volumes by air as of yet.

Hypotheses and Organization of the Thesis

There were several hypotheses held by the author during the early stages of the research work. It was hypothesized that there would be no large scale changes in the marketing processes unless there were some changes in the basic price structure within individual industries, such as consumer prices for commodities, producer prices, or transportation charges by the various modes. It was hypothesized that the changeover to air shipment would be likely to occur first in cases where one or more of the following conditions existed: (1) production and shipping areas of high concentration, (2) relatively high prices at the producer level, (3) shortages in distant markets which trigger high retail prices for short periods, (4) shifts in consumer demand allowing substantial premiums for higher quality produce, (5) changes in tariff structures which would make air transport relatively cheaper. The final chapter sheds more light on these premises.

In the chapters to follow, there will be a discussion of various aspects of the problem. In Chapter II some models and conceptualizations are presented that may help to identify the critical variables that affect the transportation of products and the prices in the market. Chapter III studies the air carrier industry involving many different variables such as technology, costs, returns, and trends. Chapter IV contains a brief view of the transportation industry in general. The costs of transporting lettuce from Salinas, California to New York City was found for the competing modes of transport, and the time and quality differentials are compared. Chapter V shows how the various findings of the study could be related to a shipper's choice of modes.

CHAPTER II

THEORY

This chapter presents a conceptual framework that will be used to help assess the potential for air transport of Arizona horticultural products. The potential for a mode of transport is highly dependent upon its relationship to other modes of transport and upon price relationships within particular commodity markets. A clear and sound method of evaluating the problem is of course hard to find, but it is hoped that the models developed in this chapter will be useful in placing the important variables in proper perspective and provide accurate insights into the future role of air transport for Arizona's horticultural products.

Western lettuce has been shipped from California on an experimental basis by several shippers, but there has been no significant volume as compared to other (surface) modes. If air transport were competitive with other modes of shipment there would probably be a significant volume shipped by air. To merely say that air rates are not competitive with surface transportation rates is a superficial and an erroneous appraisal of the potential for air transport of horticultural products. The models which follow are based on the shipping of lettuce from Arizona to the eastern markets by various possible modes. Since truck and rail modes are fairly competitive and both are highly used, the air mode will be compared to rail movement only. Truck shipment could just as easily be used in the models in the place of the rail mode.

Because lettuce shipped to an eastern market by air should reach the consumer in a fresher more appealing state, it seems appropriate to assume that lettuce in eastern markets that has been shipped by air can be considered as one product and lettuce shipped by rail a different product. A shipper has two alternative types of transportation to choose from and must decide which product he will market--either air shipped lettuce or rail shipped lettuce. A carton of lettuce at the terminal market will be called product A if it has been air shipped and product B if it has been rail shipped.

The Product-Product Model

The model used here is the product-product relationship from the theory of production economics. The decision maker in this model is the lettuce shipper who has limited capital at his disposal with which he may buy any desired resources. It is assumed that he desires to maximize returns to a given amount of capital. Lettuce will cost the shipper the same amount regardless of which mode of transportation he uses to send the lettuce to market. A constant charge per carton to cover the shipper's overhead costs will be assumed regardless of the mode of transport used. On a given day the shipper will pay a constant rate per carton for transportation charges for each mode of transportation used. This transportation charge will be defined to cover all costs of moving lettuce from the time the lettuce shipper receives the lettuce until the lettuce reaches the terminal market. To find the cost per carton to produce product A on a given day the shipper adds the following: (1) the f.o.b. price of lettuce per carton, (2) the shipper's overhead charges per carton, and (3) the transportation charges for the air shipment and other shipping or handling charges to and from the aircraft. To find the cost of producing one carton of product B on a given day the shipper adds the following: (1) the f.o.b. price of lettuce per carton, (2) the shipper's overhead charges per carton, and (3) the transportation charges for rail and any other shipping or handling charges per carton. On a given day the cost per carton for producing A or B will be assumed constant.

On a product-product surface the producer is concerned with two products and their marginal rate of transformation. With a given level of capital, there will be various combinations of A and/or B that can be produced. The iso-cost curve (iso-resource or production possibilities curve) in Figure 1 shows these combinations of

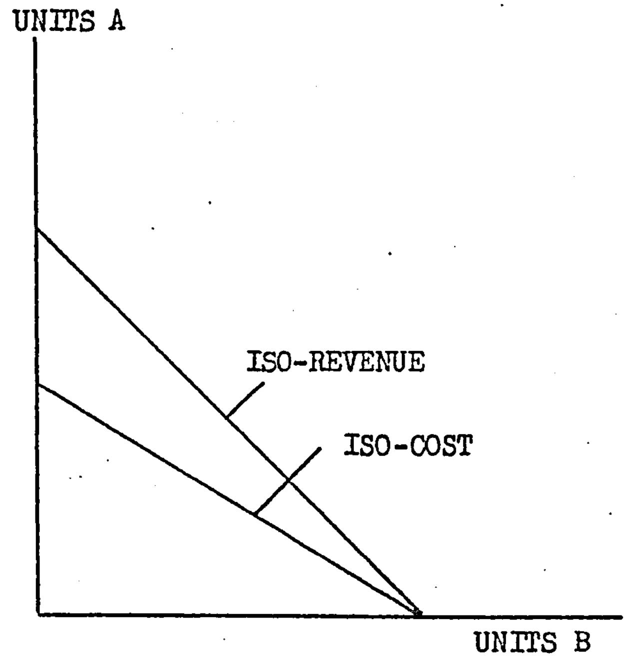

Figure 1. The Product-Product Surface

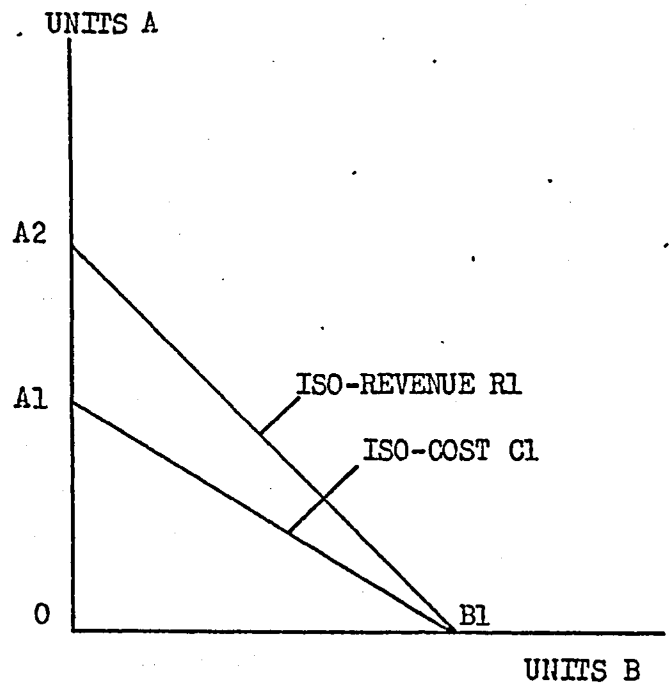

Figure 2. Product-Product Model for A and B

A and/or B, which is a linear function in the case of the lettuce shipper. This would follow because the cost of producing A and/or B remains constant on a given day regardless of the amount of either that is produced, and all resources are expressible as capital. The iso-revenue function of the firm is also included in the product-product surface diagram. This curve connects points representing combinations of A and/or B that will generate a given revenue level. For this model the selling prices are assumed constant on a given day which would give linear iso-revenue curves. There would be one curve for each different level of revenue chosen.

Figure 2 represents a situation in which the lettuce shipper's costs equal C1 dollars and revenue equals R1 dollars. The iso-cost curve, C1 and the iso-revenue curve, R1 are shown in Figure 2. The cost per unit of producing A and B is Ca and Cb respectively. The price per unit of A and B is Pa and Pb respectively. In Figure 2 the following relationships are given: Cost A = Ca, Cost B = Cb, Price A = Pa, Price B = Pb, Cost Constraint = C1, Revenue = R1. In Figure 2:

A1-B1 is the iso-cost line C1

A2-B1 is the iso-revenue line R1

Iso-cost C1/Cost per unit of producing A(Ca) $= \frac{C1}{Ca} =$ OA1

Iso-cost C1/Cost per unit of producing B(Cb) $= \frac{C1}{Cb} =$ OB1.

Iso-revenue R1/Price per unit in selling A(Pa) $= \frac{R1}{Pa} =$ OA2.

Iso-revenue R1/Price per unit in selling B(Pb) $= \frac{R1}{Pb} =$ OB1.

Also, the absolute value of the slope of the iso-cost line is equal to:

$$|S| \text{ of iso-cost line} = \frac{OA1}{OB1} = \frac{C1/Ca}{C1/Cb} = \frac{Cb}{Ca},$$

and the absolute value of the slope of the iso-revenue line is equal to:

$$|S| \text{ of iso-revenue line} = \frac{OA2}{OB1} = \frac{R1/Pa}{R1/Pb} = \frac{Pb}{Pa}.$$

Both slopes are also negative:

Slope of iso-cost = -Cb/Ca, and

Slope of iso-revenue $= \frac{-Pb}{Pa}$.

Understanding this, we can elect to talk about the absolute values of the iso-cost and iso-revenue curves only.

Product-product problem solution is normally found where the marginal rate of transformation is equal to the negative inverse of the price ratio of the two products. The marginal rate of transformation equals the slope of the iso-cost line or (dA/dB) - Cb/Ca. The negative inverse of the price ratio is equal to the iso-revenue slope -Pb/Pa. Normally one would see the following solution dA/dB = -Pb/Pa in the case of a non-linear iso-cost line. Because of the linearity of the two iso-curves, this model has three possible solutions to maximize revenue from a given set of resources. These three possible solutions are as follows:

1. If $|\text{Cost B}/\text{Cost A}| > |\text{Price B}/\text{Price A}|$, then produce all A.
2. If $|\text{Cost B}/\text{Cost A}| < |\text{Price B}/\text{Price A}|$, then produce all B.
3. If $|\text{Cost B}/\text{Cost A}| = |\text{Price B}/\text{Price A}|$, then produce any combination of A and B on the iso-cost curve.

Applications for the Product-Product Model

The product-product decision model has several applications in the context of the shipment of lettuce to market. It has been stated that in lettuce marketing situations lettuce moves by air on an experimental basis, but in no significant volume. Figure 3 gives a hypothetical situation of a shipper faced with the decision of producing either air lettuce or rail lettuce. Product A is a crate of air shipped lettuce in the Huntspoint market in New York City and product B is a crate of rail shipped lettuce in that market. Handling costs per carton are assumed to be the same per carton regardless of mode of transport used by the shipper. It is reasoned that the amount of office time and management time per carton is

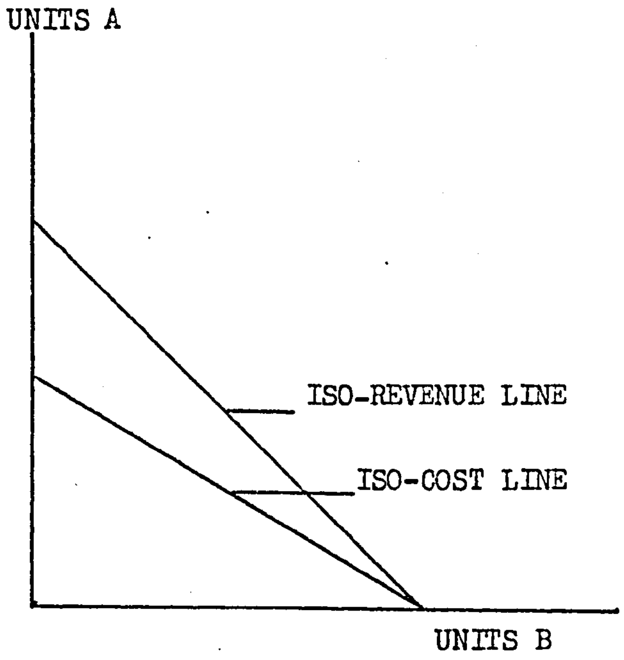

Figure 3. The Shipper's Product-Product Surface for the Huntspoint Market

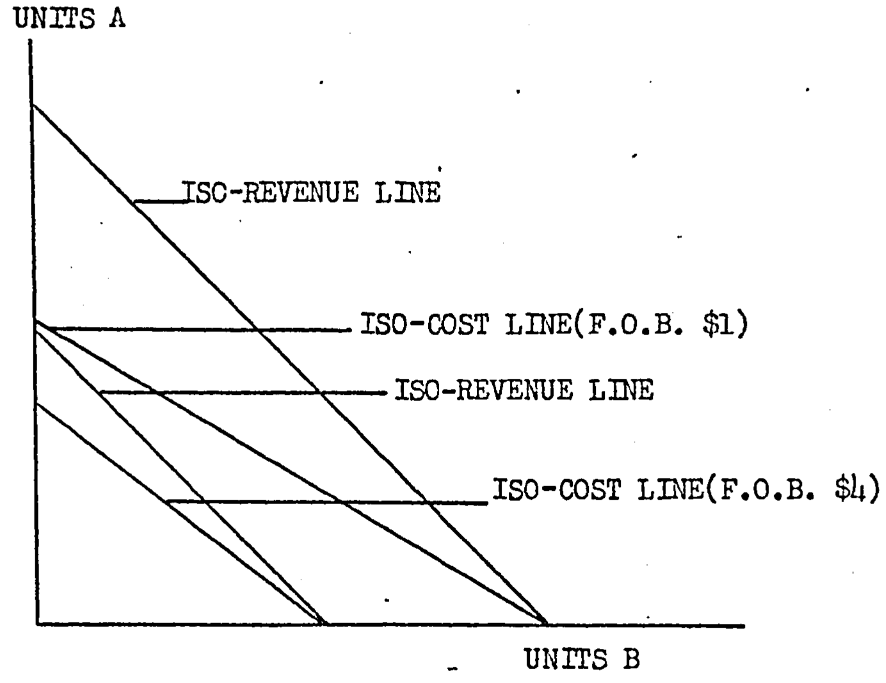

Figure 4. The Shipper's Product-Product Surface With F.O.B. Prices of $1 and $4

approximately the same whether rail, truck, or air shipment is used. The lettuce price in the producing area is a basic cost to the shipper, regardless of how he ships the commodity and therefore, is treated as fixed. It is evident that the costs per crate of A are higher than that of B since the iso-cost line in the figure intersects the two axes in the manner that they do. In this figure the selling price of the two products is the same due to no consumer differentiation between the two products A and B. Therefore, the highest iso-revenue curve that can be reached for a given cost level results from using all of the available resources in producing only product B--rail shipped lettuce. In this case the slope of the iso-revenue curve has a greater magnitude (absolute value).

Figure 4 illustrates the effect of a change in the f.o.b. price from one dollar per carton to four dollars per carton. As the f.o.b. price increases, it becomes a greater proportion of the total cost and the cost per unit of A declines relative to the cost per unit of B. In this way the absolute slope of the iso-cost curve increases in magnitude or the value of cost B/cost A increases, and the probability of shipping by air is increased. This is true because the slopes of the iso-cost curve and the iso-revenue curve become more nearly equal.

In the previous figures the revenue curves were drawn for the same selling price for both types of lettuce which yielded 45 degree lines. Figure 5 shows a case where the costs of producing are constant while the price of air shipped lettuce rises above the price of rail shipped lettuce. In Figure 5 as the price received for air shipped lettuce increases relative to the price of rail shipped lettuce, the slope of the iso-cost and iso-revenue curves become more nearly equal. The shippers will still ship by rail as long as the absolute slope of the iso-revenue curve is greater than the slope of the iso-cost curve, but the likelihood of air shipment is increased as the price of the air shipped lettuce increases relative to the price of rail lettuce.

In Figure 6 the lettuce price remains the same while the transportation charges for air shipment decrease. As the air tariffs decrease, the iso-cost line rises on the A axis while remaining fixed on the B axis. In this figure the air tariff rate would have to be lowered quite substantially before the shipper's decision would be altered.

The product-product model used in the preceding figures can be a helpful tool in analyzing the theoretical reasons for existing conditions in the market. The basic reasons why lettuce does not move by air would seem to lie in the prices usually found in the market. Some combination of higher f.o.b. price, higher price for air shipped lettuce relative to rail shipped lettuce, and lower air shipping rates relative to truck and rail rates would allow

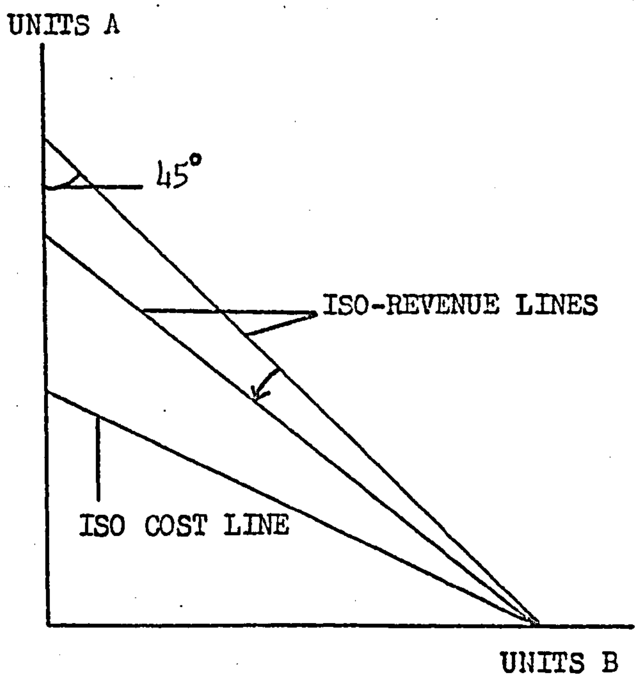

Figure 5. The Effects of a Price Premium for Air Shipped Lettuce

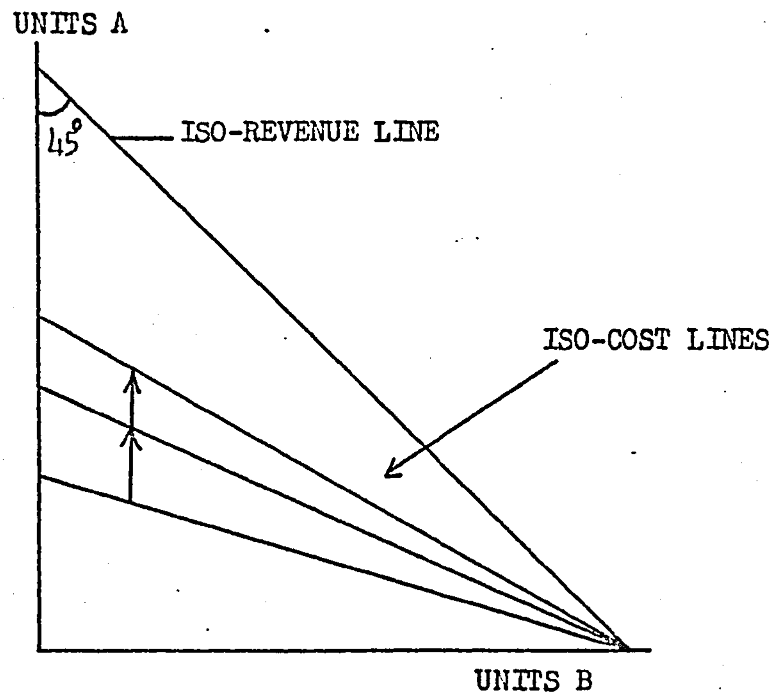

Figure 6. The Effect of Decreasing Air Shipping Charges

air shipped lettuce to become more profitable than rail or truck shipped lettuce.

The Derived Demand and Supply Model

The interaction between the demand for and the supply of a commodity determines the market price of the commodity and the quantity that is exchanged. The following model integrates the farm and retail levels of demand and supply with another concept, which is the supply of services in the market. Figure 7 is divided into part A and part B. Part A gives the farm and retail demand and supply functions for the market, and part B gives the supply of services function for the market. These functions are labeled DF (farm demand), DR (retail demand), SF (farm supply), SR (retail supply), and SS (services supply). The DF function and SR function are derived demand and supply functions, and are derived at each quantity level as follows:

$$DF = DR - SS; \; SR = SF + SS,$$

which means the farm demand is equal to the retail demand less the supply of services, and the retail supply is equal to the farm supply plus the supply of services. At the level of output Q, there is equilibrium in the model with the price of services PS equal to the retail price PR minus the farm price PF: PS = PR - PF. In this model, all prices and quantities are determined simultaneously. At

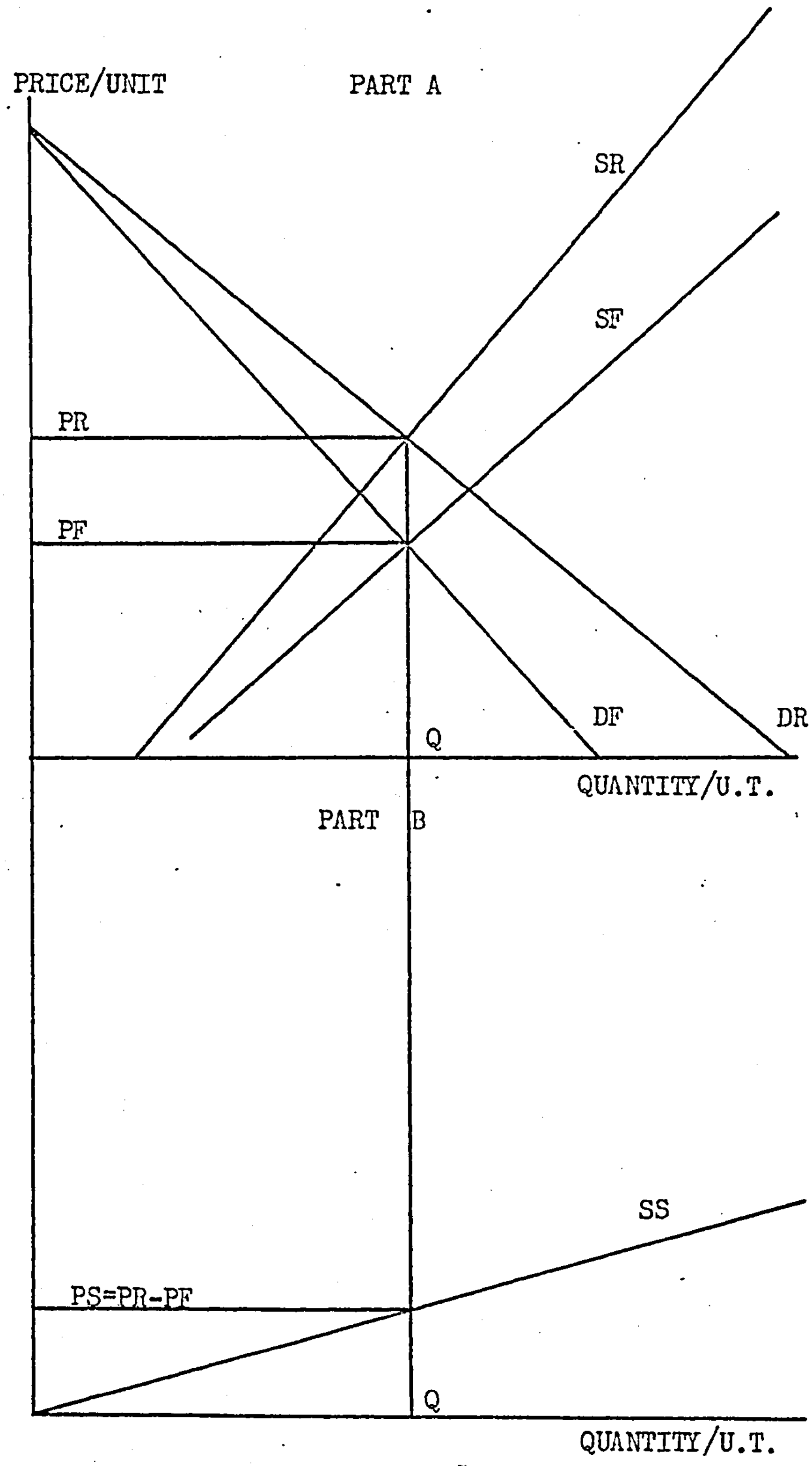

Figure 7. Derived Demand and Supply Model for a Farm Commodity

any level of quantity the price spread between the farm and retail will equal the price of services PS.

Figure 8 represents a lettuce market that is initially at equilibrium with all lettuce being shipped by rail. The supply of services is given as positively sloped, although it may be horizontal or negatively sloped in any given market situation. The solid lines depict the demand and supply curves at initial equilibrium with no air shipments of lettuce (SSo, SFo, SRo, DFo, DRo). Prices at the three levels are PSo, PFo, and PRo. Next it is assumed that all lettuce must be shipped by air, therefore, forcing a higher per unit cost for transportation charges. Fox (1953, p. 18) points out that transportation costs are usually constant per unit, so it is assumed here that the supply of services will shift upward but remain parallel to the first supply of services curve. The broken line SS1 is the new supply of services curve. The broken lines DF1 and SR1 are the new demand at the farm level and the supply at the retail level. The equilibrium prices and quantity: PS1 = PR1 - PF1, Q1. At a smaller equilibrium quantity, the retail price PR1 is now higher, the farm price PF1 is lower, and the cost of services PS1 is higher. This would be the expected result of changing to air shipped lettuce.

In Figure 9 the final equilibrium prices and quantity from Figure 8 (PS1 = PR1 - PF1, Q1) are used as the initial equilibrium. The related demand and supply

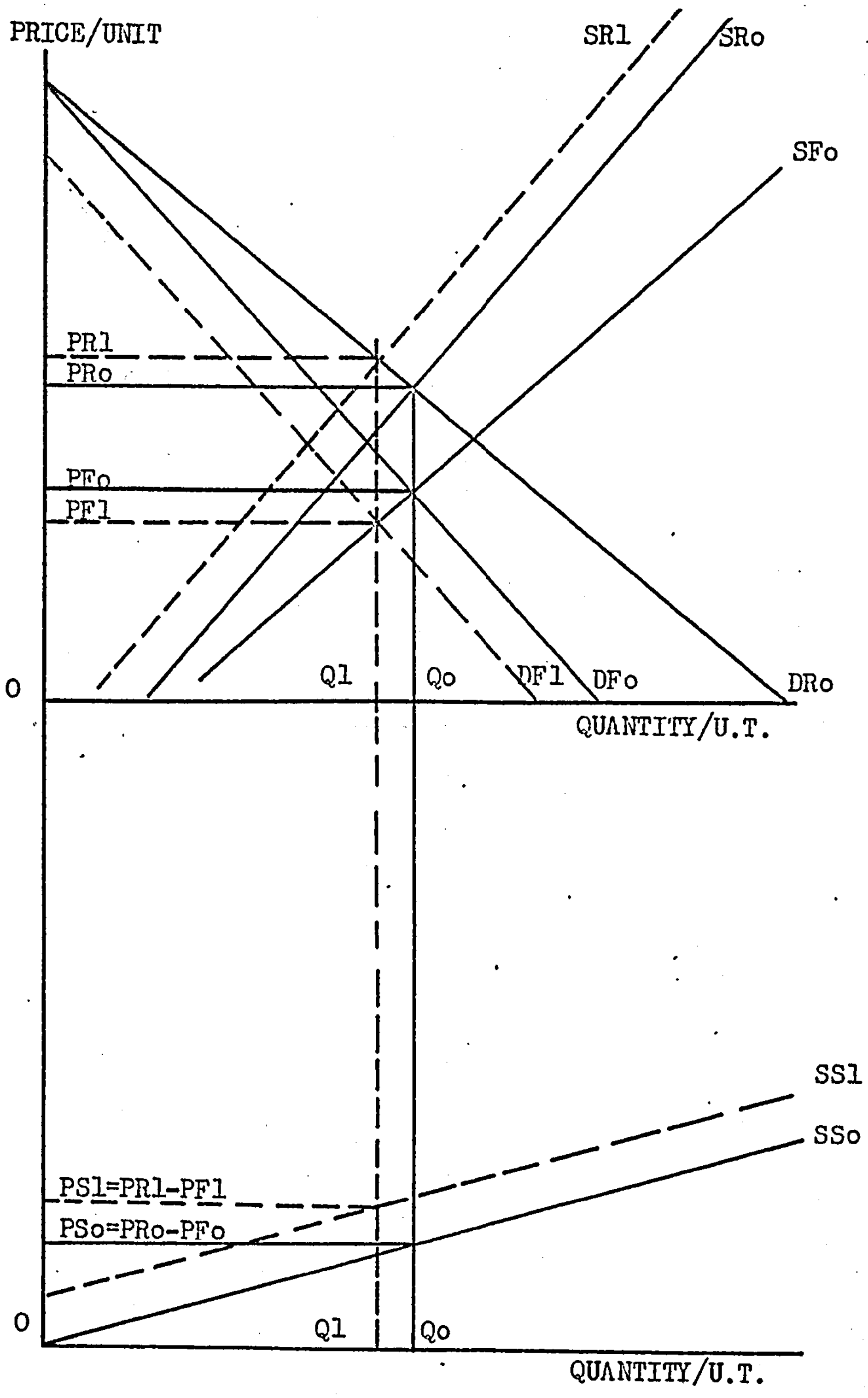

Figure 8. Derived Demand and Supply Model for Lettuce: Changing to Air Shipment of Lettuce

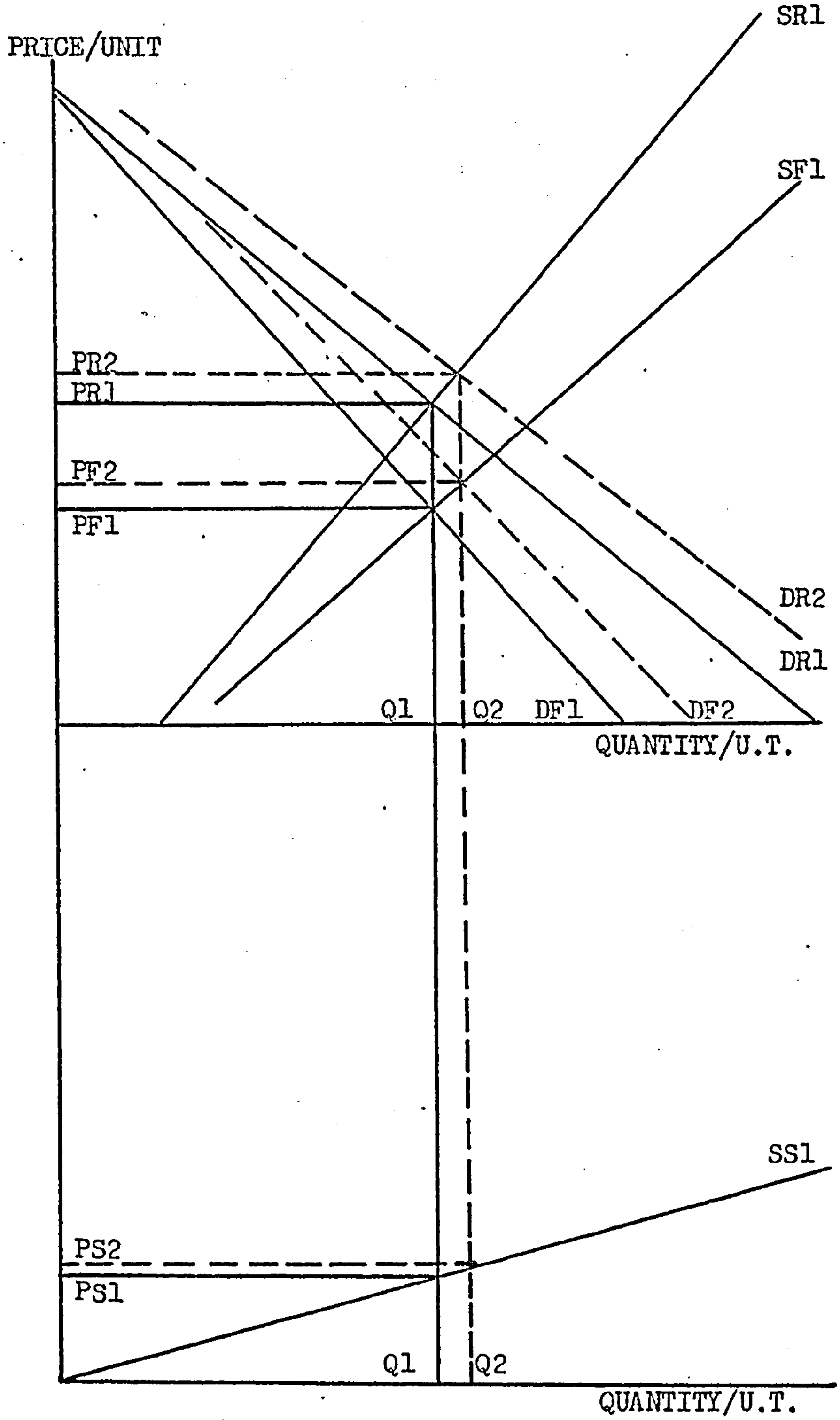

Figure 9. Derived Demand and Supply Model for Lettuce: A Price Premium for Air Shipped Lettuce

curves for this price and quantity are solid lines in Figure 9. It is assumed that because a higher quality of lettuce is now being marketed, the consumers, being responsive to quality and service, shift their demand upward and to the right. The new retail demand curve is DR2, and the farm demand is DF2. Prices and quantity at the new equilibrium are now: PS2 = PR2 - PF2 and Q2. The effect of this demand shift would be to cause higher prices at the farm and retail levels, as well as a higher quantity Q2. The final cost of services PS2 would also be higher, meaning retail prices would rise a little more than farm prices.

CHAPTER III

THE AIRLINE INDUSTRY

Historically, the airline industry of the United States has been a dynamic institution. Before World War II the industry was really just starting to take roots, and the industry of today is far removed from the pre-war days. Mail carrying and military use were some of the primary reasons for the early airline's existence, while passenger flights were of a very small scale. The standard policy of many airlines was such that oftentimes passengers would be required to give up their seat at any time so that mail could be picked up at a stop. Mail was a higher revenue producing load than the passengers were, and the mail therefore, received first priority. The growth of the airlines has been largely dependent upon the government's aid at times since the planes in existence before the jets appeared were on the whole very uneconomical in most commercial uses. The piston prop airplane was used by the air carriers for commercial flights, and these planes were uneconomical in all but a few high revenue producing uses. Many airlines reported losses in all-cargo operations, and all-cargo carriers as a group showed losses in six of the years 1955 through 1964 (Brewer, 1966a, pp. vi-viii).

The jet age opened a completely new era for the domestic airlines. Jet aircraft are economically superior to piston-prop aircraft in commercial operation. Also, the jet aircraft introduced in the United States have much greater physical carrying capacity than the piston aircraft. Payloads and speeds of the jet aircraft first available were about triple that of the existing piston aircraft in use. Significant changes within the airline industry occurred along with the introduction of the jet aircraft.

In the first full year of domestic jet service in 1959 there were 84 jet aircraft in operation. Ten years later, in 1968, the domestic airlines had 1,700 jet aircraft in operation. The percentage of traffic carried by jet aircraft reached 94.4 per cent of the total of 114 billion revenue passenger miles carried in 1968. The jet freighters were first introduced in 1963. By early 1966 there were 55 all-cargo aircraft in operation. The major build-up of jet freighters has occurred since 1966, and by early 1969 there were 312 all-cargo or quick change convertible jets in cargo service. The changes made since the inception of the jet aircraft have significantly changed the nature of the transportation industry. The distribution of inter-city revenue passenger miles performed by public, inter-city transporters (for rail, bus, and airplane) indicates that air mode's share was 39.3

per cent in 1958 compared to 72.5 per cent in 1968. Since 1958 the airlines have increased their passenger mileage by 245 per cent, while private auto increased 60 per cent. The average charge per ton-mile in 1958 was 25.78 cents as compared to the 1969 figure of 19.51 cents (Air Transport Association of America [ATA], 1969, pp. 12-13). Today the passenger operations receive high priority and passenger treatment has been greatly improved over that of the early days of passenger flight. Airline facilities have changed along with the changes in the industry. Although there are many undeveloped facets of ground operations, the changes that have been made are significant. Cargo handling has received increasing attention and large scale investments of one to two billion dollars are currently expected for the next ten years.

Airline Costs, Revenues, and Related Data

Airline costs and revenues are probably the primary determinants of current air tariff rates. Future air tariff rates will partly depend on any effects new technology has on the air carriers' operating costs and revenues. The effect of new technology and management upon tariff rates can be forecasted, but first a working knowledge of the nature of airline operating expenses and revenues is needed. A brief outline of the nature of airline operating expenses and revenues and a comparison of several aircraft on both a physical and an economic basis will be presented. Also, trends in air carrier costs, revenues, and related data will be presented.

The Civil Aeronautics Board's (CAB) cost and revenue reports use various cost and revenue formulas which seem to be accepted by the air traffic industry. Although other formulas could be used to analyze costs and revenues, the CAB convention will be used throughout this chapter in the cost and revenue analysis.

Total operating costs of an air carrier include all costs incurred while in business. It would be the sum of all expenditures and accounts payable incurred for a given time period. Total operating costs are composed of both direct operating costs and indirect operating costs. Direct operating costs are related to costs of operating the aircraft, including crews' salaries, fuel, maintenance, and depreciation. Indirect operating costs include costs of loading and unloading cargo, promotion, traffic agents, ground equipment and administrative functions, landing fees, and ground servicing. Total revenues of an air carrier measure the inflow of money for services performed. The rate structure or tariff and the amount of cargo carried determines an air carrier's revenue.

Cargo ton-miles carried expresses an air carrier's output. A cargo ton-mile carried is equal to one ton of cargo hauled one mile. In reports to the CAB a carrier may measure revenue cargo ton-miles separately from the available cargo ton-miles. Available cargo ton-miles relates to the amount of output the carrier could have had if all aircraft had flown with full capacity loads, while revenue ton-miles is the amount of actual output. Load factor expresses the ratio of revenue ton-miles to available ton-miles in per cent. This is a measure of how actual output compares with potential output. Utilization is the number of hours a plane is operated per day. Load factor and utilization are important determinants of profitability of the carrier.

Often ratios may be more directly related to profitability than absolute magnitudes. The reports to the CAB filed by the air carriers express costs and revenues as ratios as well as by total costs and revenue amounts. In Aircraft Operating Costs and Performance Report, the CAB uses the following formulas to report air carrier activities (CAB, 1968, pp. 123-129):

$$\text{Total aircraft operating expenses per revenue ton-mile} = \frac{\text{Total aircraft operating expense per aircraft mile}}{\text{Average revenue tons per aircraft mile}}$$

$$\text{Total aircraft operating expense per available ton-mile} = \frac{\text{Total aircraft operating expense per aircraft mile}}{\text{Average available tons per revenue aircraft mile}}$$

$$\text{Total aircraft operating revenue per revenue ton-mile} = \frac{\text{Total aircraft operating revenue per aircraft mile}}{\text{Average revenue tons per aircraft mile}}.$$

Total aircraft operating expenses per revenue ton-mile is a measure of actual costs while aircraft operating expenses per available ton-mile measures cost potential. Direct operating and indirect operating expenses can be expressed in similar ratio formulas. The difference between operating revenue per revenue ton-mile and operating expenses per revenue ton-mile equals profit or loss per revenue ton-mile.

The Air Cargo Fleet

The present air cargo fleet is composed mostly of Boeing model B-707 and the Douglas model DC-8 aircraft. Although there are several models of these planes, the basic configuration is similar. The DC-8 model 62CF has a maximum ramp weight of 353,000 pounds, and will carry a gross payload of 92,830 pounds. The minimum density of cargo that will just fill the 62CF is 9.8 pounds per cubic foot. With palletized loads the payload is 87,373 pounds with a minimum cargo density needed to fill the plane of 11.0 pounds per cubic foot. The B-707-320C has about the same capability in weight carrying ability as the 62CF. The direct operating cost in cents per ton-mile (statute) for the 707-320C convertible cargo configuration is shown in Figure 10 as estimated by the manufacturer. There are several versions of medium size jets like the DC-9 and the B-720 which carry smaller loads and are not as economical

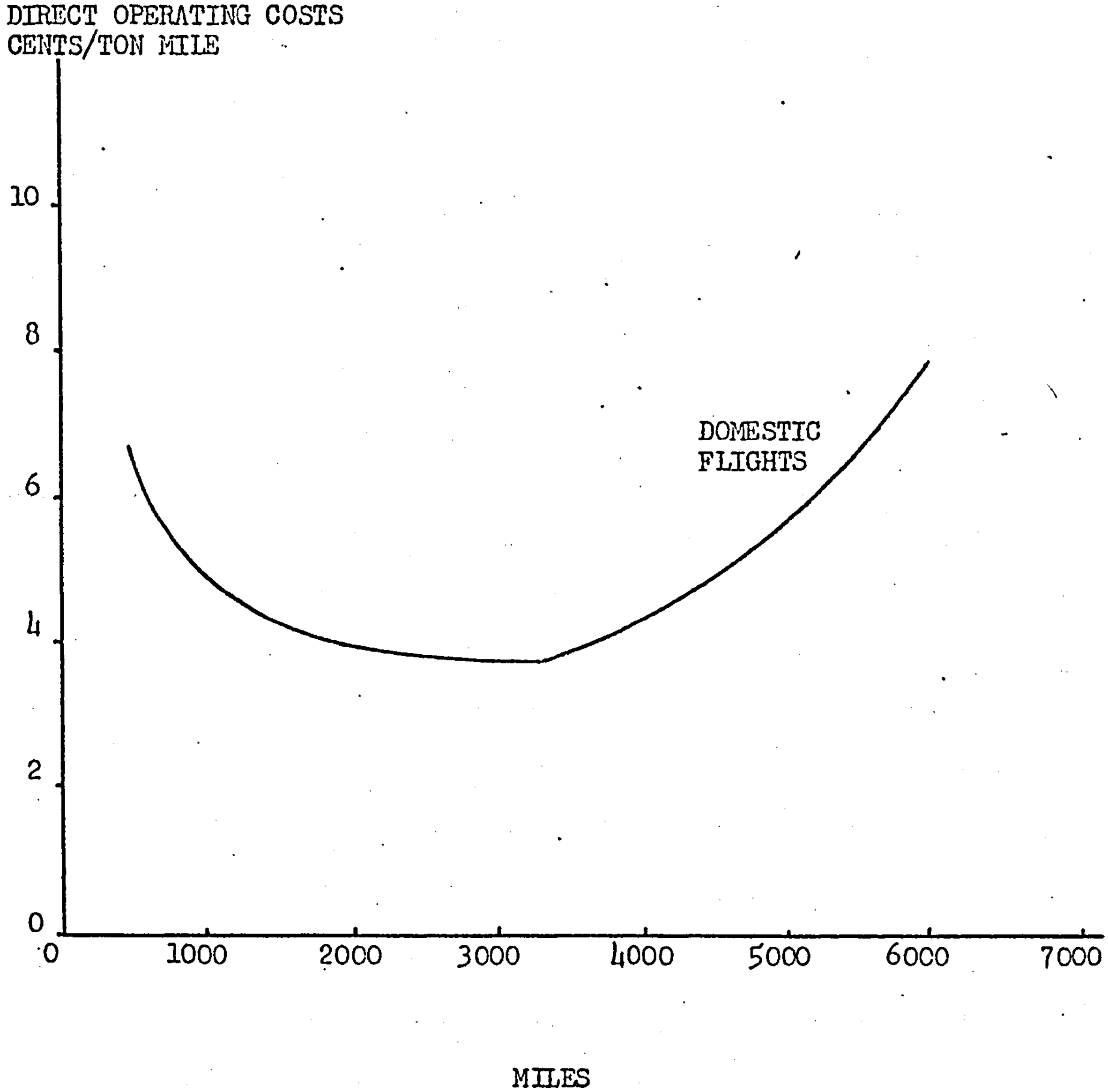

Figure 10. Operating Costs for the B-707-320C Convertible for Domestic Operations, 1967 ATA

in long range operations as either the 62CF or the 707-320C. These aircraft were not examined in this study since agricultural commodities are hauled mainly on the longer flights in DC-8 and B-707 models.

The New Generation of Aircraft

The new generation of aircraft which are of greatest interest to most people in the perishables marketing system are the Boeing 747 and Lockheed L-500 (civilian model of the C5A), which will be delivered in the early 1970's. The B-747 has a length of 231 feet and a wing span of 195 feet. The main interior compartment will accept two rows of 8 x 8 containers of up to 40 foot lengths, and the length of this main compartment is 185 feet. The maximum taxi weight is 778,000 pounds, and maximum payload of the freighter is 259,248 pounds. The volume of the 747 compartments is 23,690 cubic feet, giving a density factor of 10.94 pounds with bulk loads. The direct operating cost in cents per ton-mile for the 747 freighter is shown in Figure 11 as estimated by the manufacturer.

The Lockheed C-5A, which has been designed for military use, is somewhat similar to the L-500 model but has less lift capacity. The L-500 will be 230.6 feet long and has a cargo volume of 58,250 cubic feet. The maximum ramp weight will be 833,200 pounds, and maximum gross payload will be 300,000 pounds. The density factor of the

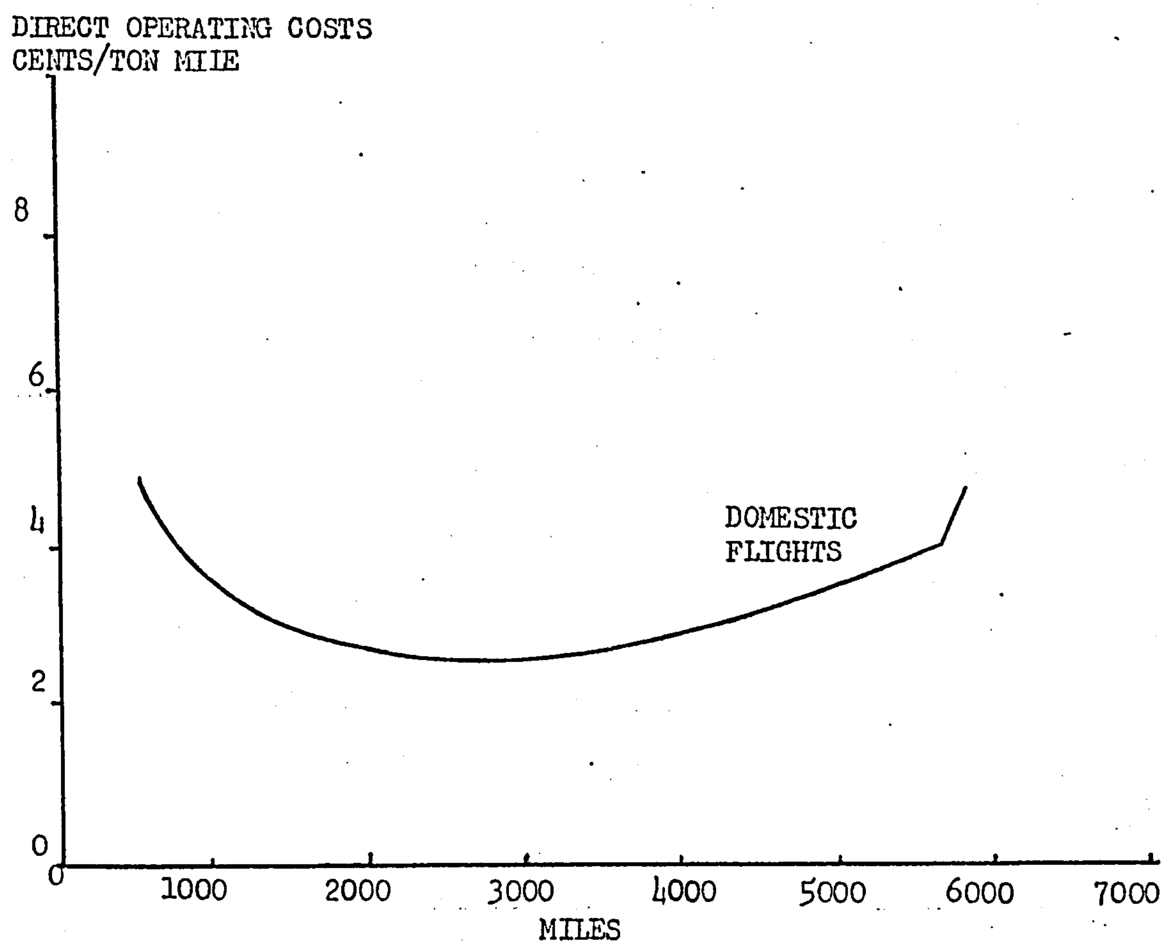

Figure 11. Estimated Costs for the 747 Freighter for Domestic Operations, 1967 ATA

L-500 will be much lower due to the large volume. With maximum gross payloads the density factor is 5.15 pounds per cubic foot. The direct operating cost in cents per ton-mile is shown in Figure 12 as estimated by the manufacturer. The manufacturer's estimates on the operating costs of the B-747 and L-500 will be assumed to be accurate. Both of these aircraft are designed so that the main compartments can be loaded from the front with mechanized equipment. The planes have steel rollers built into the floors so that containers can be pushed in and out easily. Direct operating costs are lower than the B-707 or the DC-8-62CF. The L-500's D.O.C. in Figure 12 is about 30 per cent less than the D.O. cost for the 707-320C. Costs for loading cargo should also be reduced on the B-747 and L-500 due to the well designed cargo holds which these planes will offer.

The Potentials of Various Aircraft

Professor Brewer has developed some interesting data regarding the comparative potentials of various aircraft in his Air Cargo Comes of Age (Brewer, 1966a). In Table 4, the capabilities of the aircraft based on 60 per cent load factors, 7.75 hours per day utilization of piston planes, and 9.0 hours per day utilization of jet aircraft (including turbine) are shown, based on Brewer's work. Brewer's all-cargo-configuration data were based on total

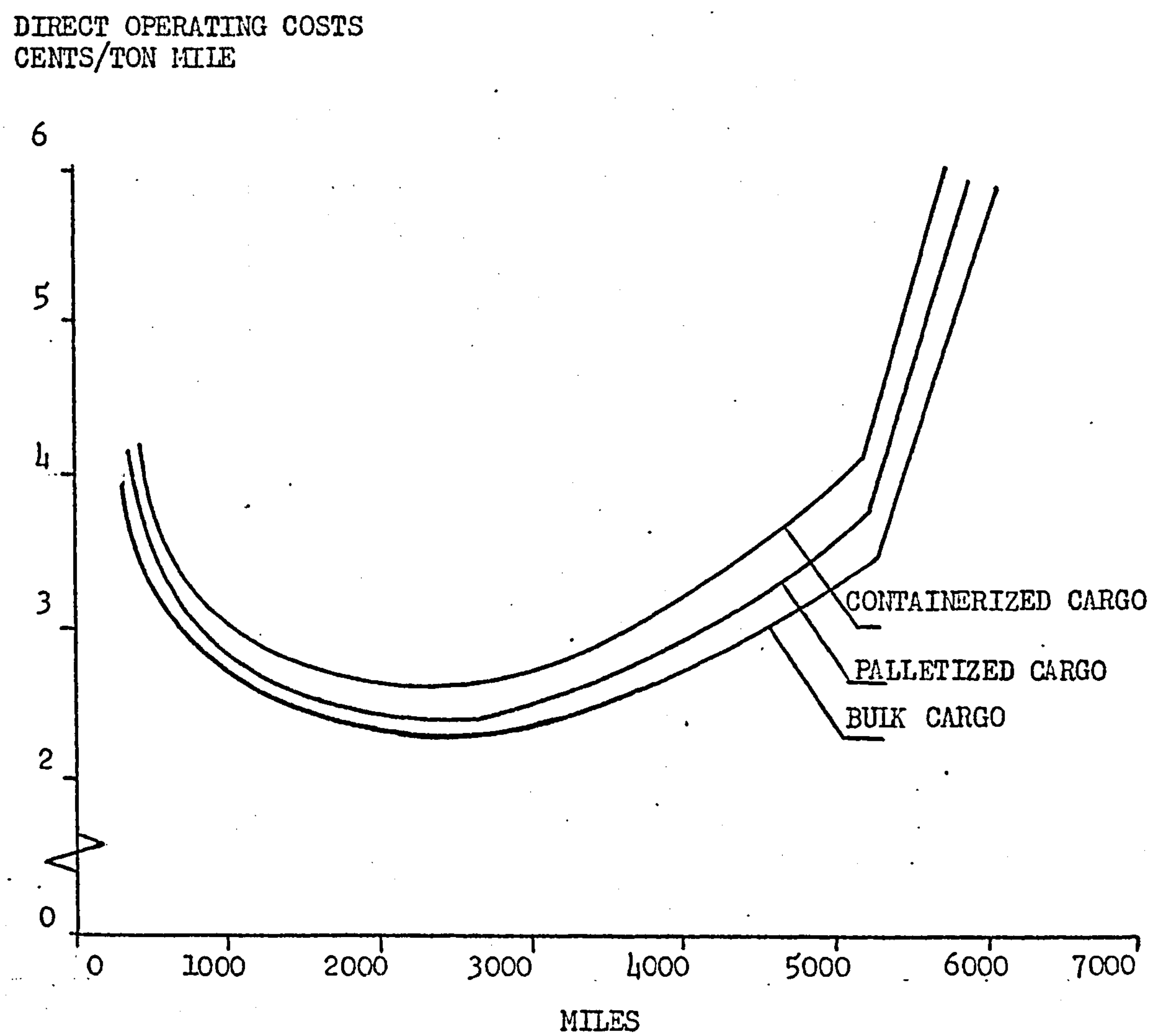

Figure 12. Estimated Operating Costs for the L-500 Cargo Configuration Aircraft

Table 4. Cargo Potential of Selected Aircraft

	Cargo Tons	Daily Cargo Ton Miles	Total O.C. (2/3 D.O.C.) (1/3 I.O.C.)	Cost Per Cargo Ton Mile (2/3 D.O.C.) (1/3 I.O.C.)
DC-3	3.5	4,069	1,203.20	29.57
C-46	6.2	8,649	1,715.85	19.84
DC-4	8.0	11,780	2,540.07	21.56
DC 6A (6B)	16.5	31,969	3,458.44	10.82
1049-H	17.5	33,906	4,533.75	13.37
DC-7F (7C)	16.5	35,166	7,576.59	21.55
CL 44	28.0	86,940	8,756.10	10.07
DC-8F (8)	45.0	192,375	10,733.00	5.60
B-707-320C	45.0	192,375	12,119.62	6.30
B-747	110.0	495,000	18,562.50	3.75

Source: The data for this table were taken from Brewer's (1966a) Air Cargo Comes of Age, pp. 18-19 and from Brewer's (1966b) The Nature of Air Cargo Costs, pp. 6-7.

operating costs composed of two-thirds direct operating costs and one-third indirect operating costs. The cost per cargo-ton mile (i.e., revenue-ton miles) for the DC-3 is 29.57 as compared to 5.6 for a DC-8F jet aircraft. The DC-3 has a 24 seat capacity or a 3.5 ton cargo capacity in an all cargo configuration. Brewer estimated the capacity of the B-747 to be 400 passengers or 110 tons of cargo in all cargo use, which is conservative for the weight. Based on this, Brewer compares the 5.6 cents per cargo ton-mile for the DC-8F to 3.75 cents per cargo ton-mile for the B-747. Brewer concludes that the B-747 would lower total costs of operation 35 per cent over that of the DC-8F. The physical capabilities of the B-747 as compared to the DC-3, measured in daily cargo ton-miles that can be flown, is impressive, being over 100 times as great. A forecast of lower future air tariff rates for the air carriers would seem justified based on the predicted lower costs of the B-747 and L-500. However, the potential costs and actual costs may be quite divergent in the airline industry. Rates are highly dependent upon the actual costs incurred by the airlines, regardless of the potential costs offered by their aircraft and equipment. In Figure 13 it is seen that there can be a great deal of variation in the CAB reported figure for direct operating costs per available seat miles from year to year for one type of aircraft (Miller and Sawers, 1968). These data also show the great

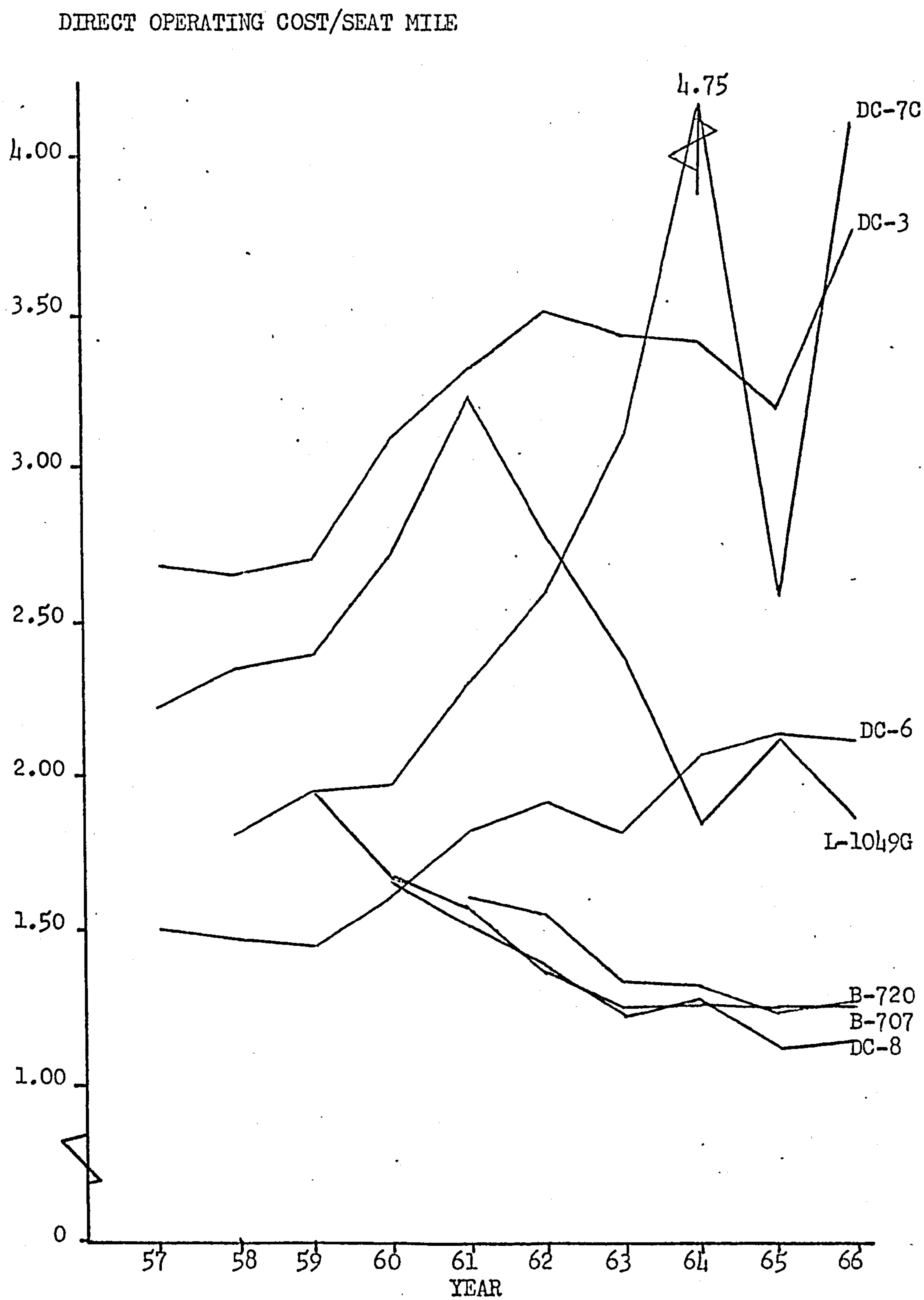

Figure 13. Selected Aircraft Operating Costs, Domestic Trunk Lines

variation in actual operating costs per available seat mile among different aircraft. Figure 14 shows the domestic carriers' operating expenses per revenue ton mile (actual costs) and the operating expenses per available ton mile (potential costs) for cargo service in 1963-1968. It seems evident that potential costs would have only limited use in forecasting air tariff rates.

The Actual Costs and Revenues of the Air Carriers

The actual costs and revenues of the air carriers have been thoroughly covered in the CAB's (1969) Trends in All-Cargo Service. It seemed that a look into the trends during the 1960's might be useful in helping assess the probable impact of the B-747 and L-500 and similar aircraft during the 1970's. The report covers selected United States certificated route air carriers for fiscal and calendar year periods June 30, 1963 to June 30, 1968 in scheduled all-cargo service. This report covered all flights scheduled primarily for the transportation of cargo including freight, mail, and express. Cargo moving in the belly of aircraft engaged in passenger services was not included in this report.

The CAB figures for operating expenses per revenue ton-mile, operating revenues per revenue ton-mile, and operating expenses per available ton-mile were adjusted to

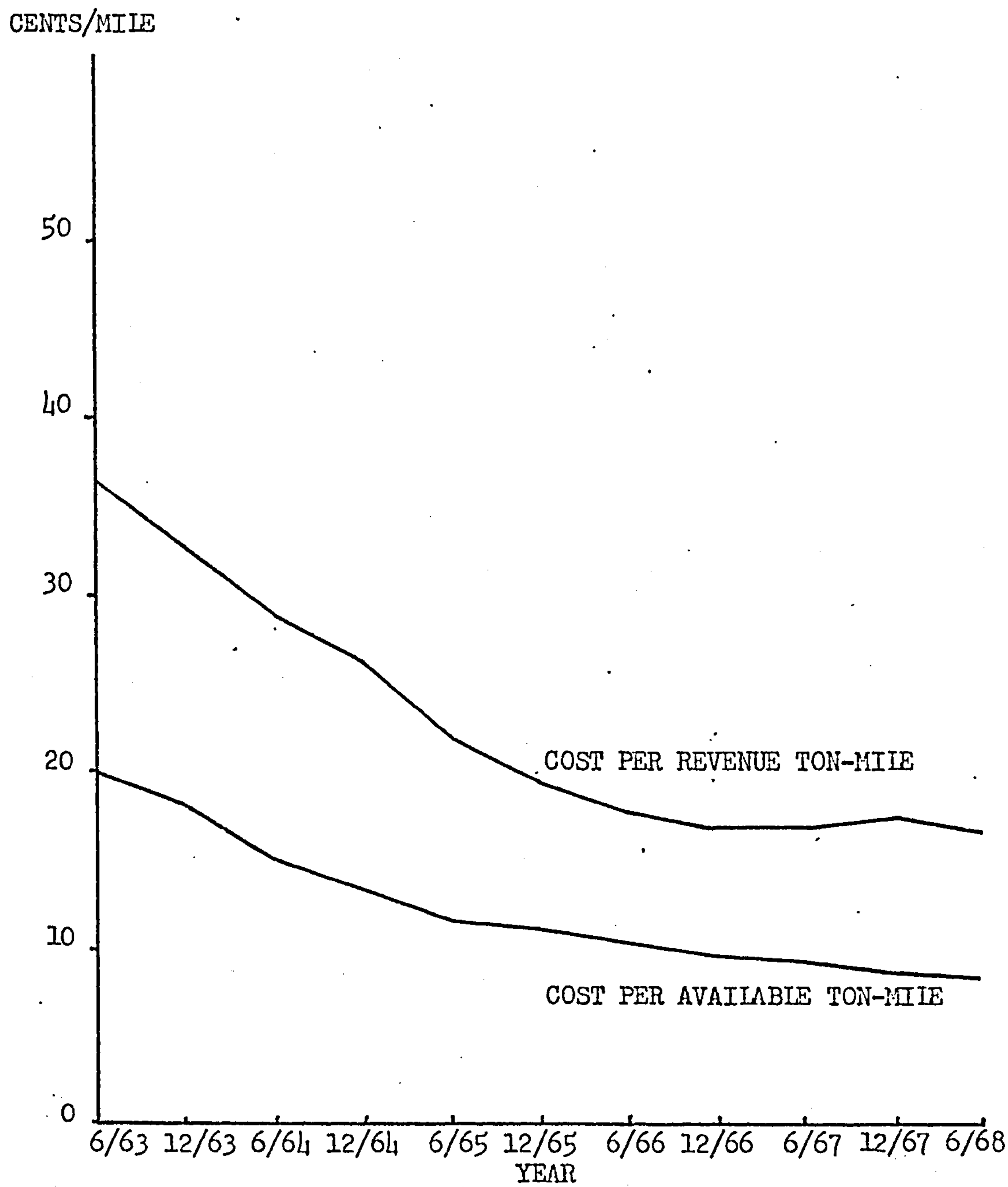

Figure 14. Operating Expenses: By Available Ton-Miles and by Revenue Ton-Miles, Total All Carriers

remove inflationary price effects.[1] Figures 15 through 19 show load factors and operating costs and revenues per revenue ton-mile for individual groups according to type of service rendered and for the total group. Figures 15 and 17 show that the domestic and international/territorial combination carriers have had similar trends in operating expenses.[2] The importance of the load-factor can be seen by comparing profit and load-factors in the Figures 15 through 19. In most cases profit moves up and down with load factors. In Figure 15, the domestic combination carriers had only two periods of profit and their load factor never rose above 54 per cent. Although these carriers have lowered expenses dramatically, they have not been profitable. In Figure 16, the domestic all-cargo carriers had profit in two periods when their load factor was near 70 per cent but losses in other periods when load factors were lower. In Figure 17, the international combination carriers reported profits in all but three periods and have generally pushed their load factors higher until recently. Their maximum profit coincides with the maximum load factor. In Figure 18, the international

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1. The G.N.P. implicit price deflator for the private sector was used to adjust the data for changes in the general purchasing power of the dollar.

2. Combination carriers are those airlines that operate scheduled passenger service in addition to all cargo flights. However, the cost figures reported here cover only the all cargo flights.

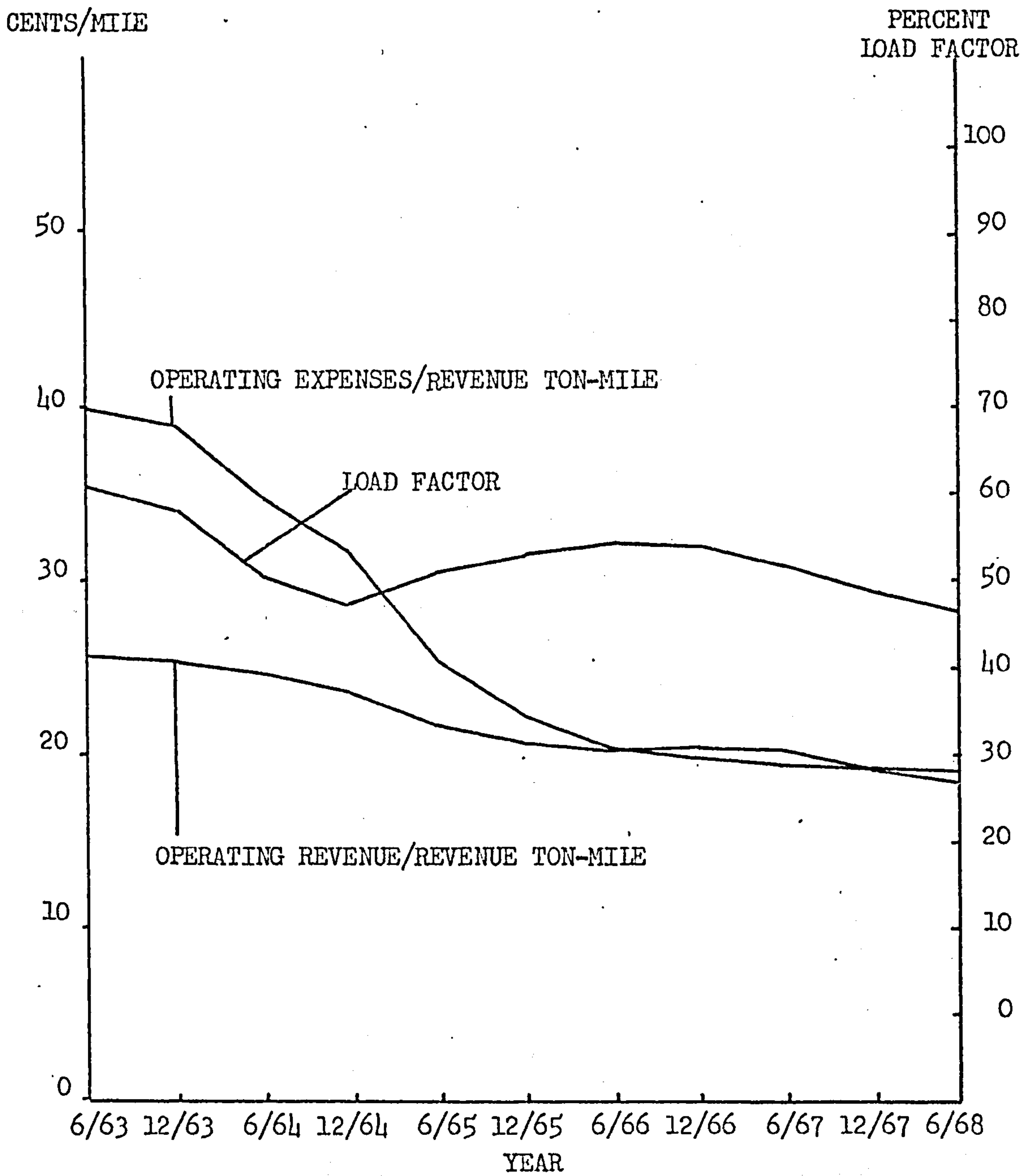

Figure 15. Domestic Combination Carriers' Expenses, Revenues, and Load Factors

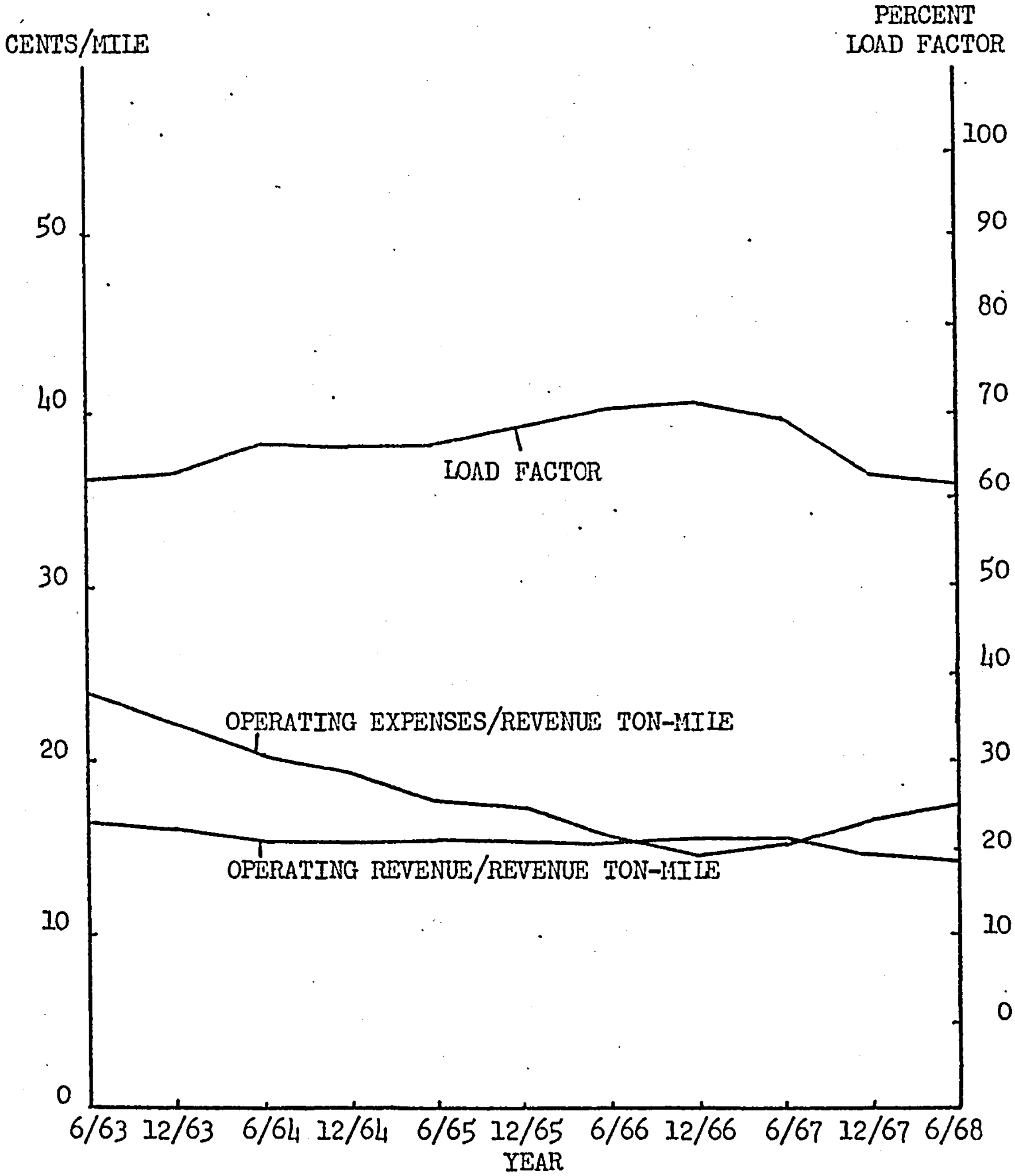

Figure 16. Domestic All-Cargo Carriers' Expenses, Revenues, and Load Factors

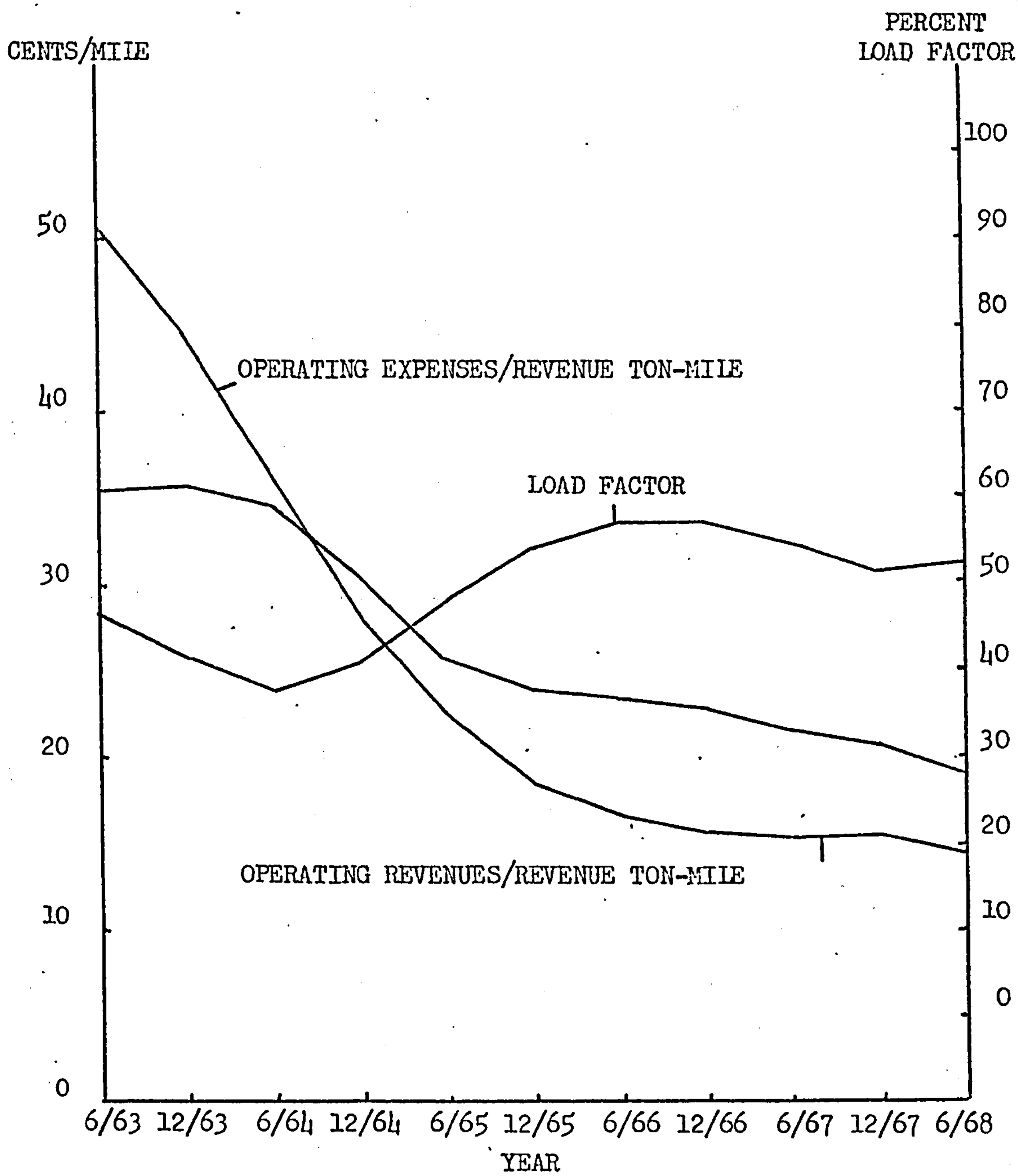

Figure 17. International/Territorial Combination Carriers' Expenses, Revenues, and Load Factors

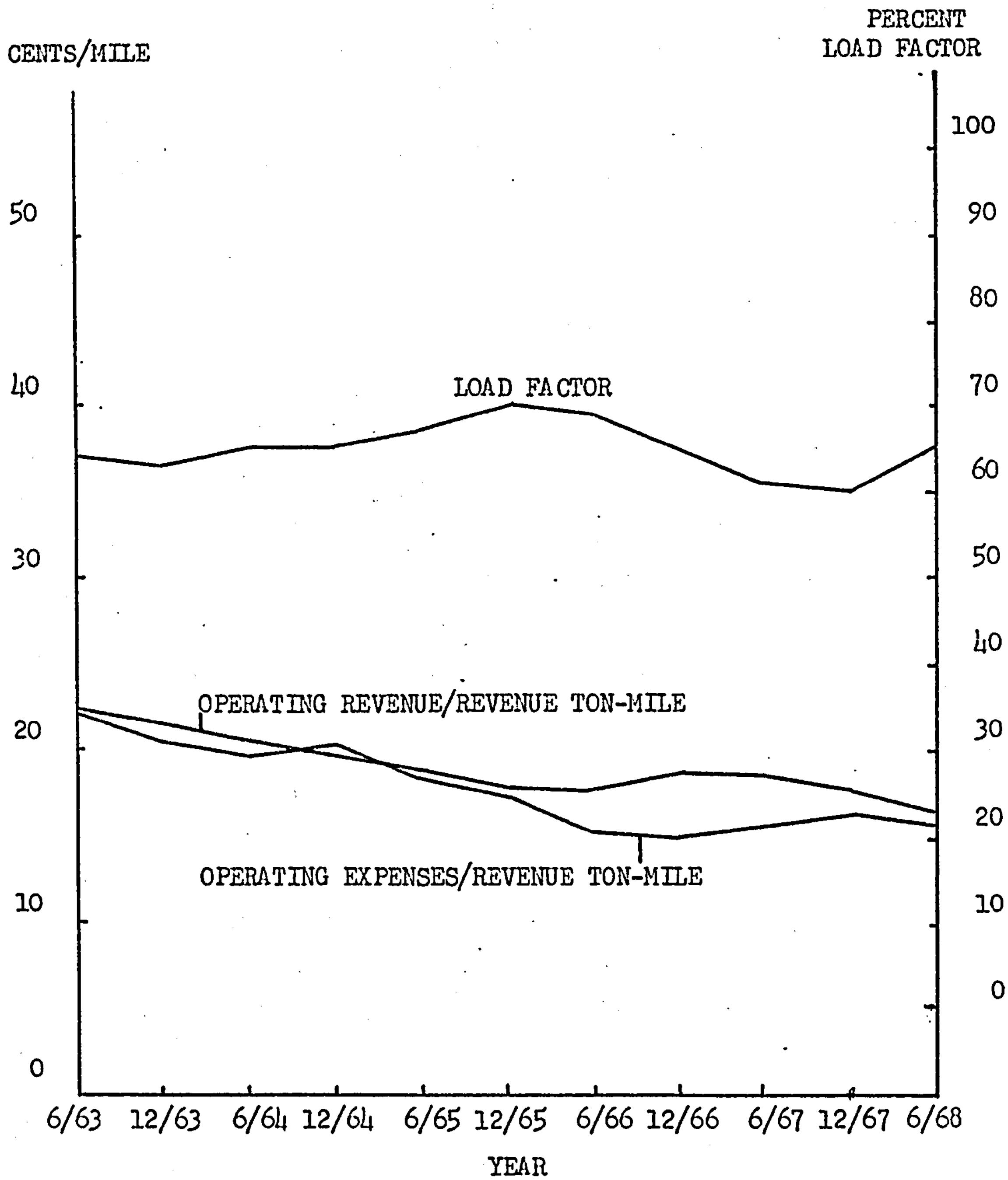

Figure 18. International/Territorial All-Cargo Carriers' Expenses, Revenues, and Load Factors

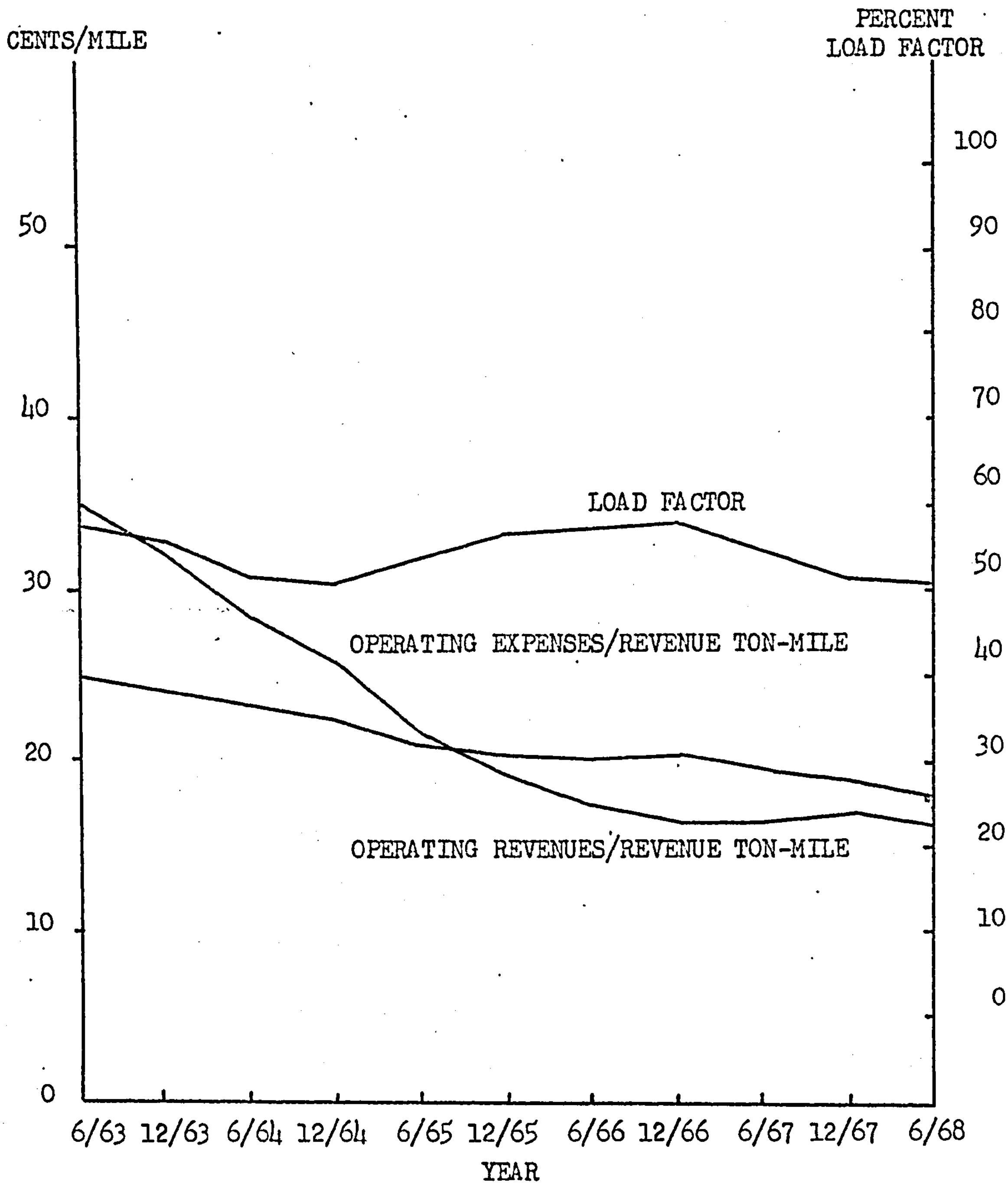

Figure 19. Averages: Domestic and International/ Territorial Combination-and All-Cargo Carriers' Expenses, Revenues, and Load Factors

all-cargo carriers had profits in all but one period and had load factors above 59 per cent in all periods. In Figure 19, all carriers' averages show that the load factors are from 50 to 60 per cent on the average and that profit and load-factor are closely related.

For the carrier industry in general, costs have been significantly reduced. Costs per revenue ton-mile appear to be leveling out in the last two to three years. In Figure 19 the leveling of costs may be due to the falling load factor during the last five periods.

The operating expenses per available ton-mile for all carriers are shown in Figure 20. These operating expenses per available ton-mile are based on the same total expenses used to derive operating expenses per revenue ton-mile. The operating expense per available ton-mile reflects the industry's potential cost. The actual cost would surely be higher than this because increasing the load factor to near 100 per cent would result in increased total costs of handling, bookkeeping, and fuel. On June 30, 1968 the operating expense per available ton-mile (8.60 cents) for all carriers can be derived by multiplying the operating expense per revenue ton-mile for all carriers (16.76) by their load factor (51.3 per cent).

In Figure 19, the operating expenses begin to level out in June 1966 which seems to be due to decreasing load factors for all carriers in the survey. Figure 20

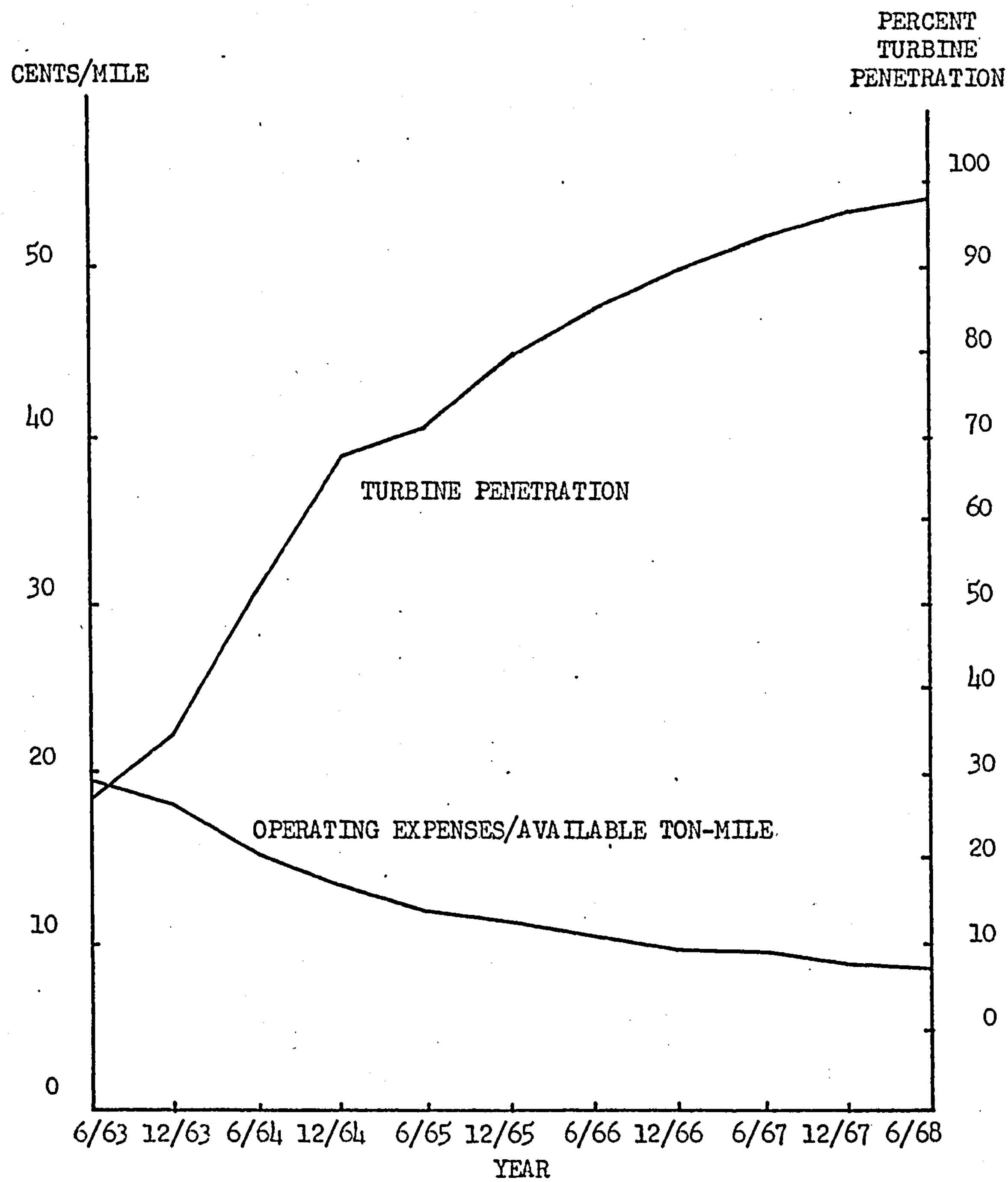

Figure 20. All Carriers' Operating Expenses/Available Ton-Mile and Turbine Penetration -- This includes both turboprop and jet aircraft.

indicates the operating expenses per available ton-mile did not level out as noticeably as operating expenses per revenue ton-mile. It would seem that if there were a continuation of the present generation of jet aircraft there would be a leveling out of the expenses over time. The turbine penetration scale (which includes turboprop and jet aircraft) in Figure 20 indicates that once 100 per cent jet aircraft is reached the trend of operating costs per available ton-mile would level out. The substantial savings made by taking piston models out of service would cease at 100 per cent penetration by turbine models. Also, present jet aircraft are operated by firms of a scale which seem to include many of the existing economies of scale, so increases in the number of jet aircraft would not be expected to lower costs substantially.

Turbine penetration is measured as scheduled ton-miles flown with turbine aircraft as a per cent of total scheduled all-cargo revenue ton-miles carried by selected certificated route air carriers. In Figure 20, this shows the rapid change that has occurred as piston planes were replaced by jet aircraft. The penetration line is nearly a mirror image of the operating expenses per available ton-mile for all carriers. The major reason for the trend in operating expenses per available ton-mile seems to be the switch to turbine aircraft which are much more efficient than piston aircraft.

Figure 21 relates operating expenses per revenue ton-miles to reported total revenue ton-miles carried by the industry. This illustrates that economies of scale within firms may account for part of the trend in operating expenses per available ton-mile in Figure 21. There can be economies in management and maintenance as greater volume per airline is attained. The economies of size effect is probably secondary to the effect of the turbine penetration. This measurement of revenue ton-miles carried by the industry is a rough measurement of the growth of these carriers during the period. In Figure 19 it was shown that the load factor of the total group ranged between 51 to 59 per cent. Total available ton-miles per year would be found by dividing revenue ton-miles carried by the load factor in each appropriate year. Figure 22 gives the available ton-miles per year of all carriers in the group.

Several things seem evident in regard to the material presented in this chapter. The aircraft manufacturer's cost estimates invariably indicate that the operating costs and tariff rates could be lower in the future. There are several hundred orders in for the new passenger and cargo aircraft like the B-747 and L-500. This would seem to indicate that the carriers have accepted these cost estimates made by the aircraft manufacturers. However, it also seems that potential costs may be misleading due to the possible difficulties in achieving

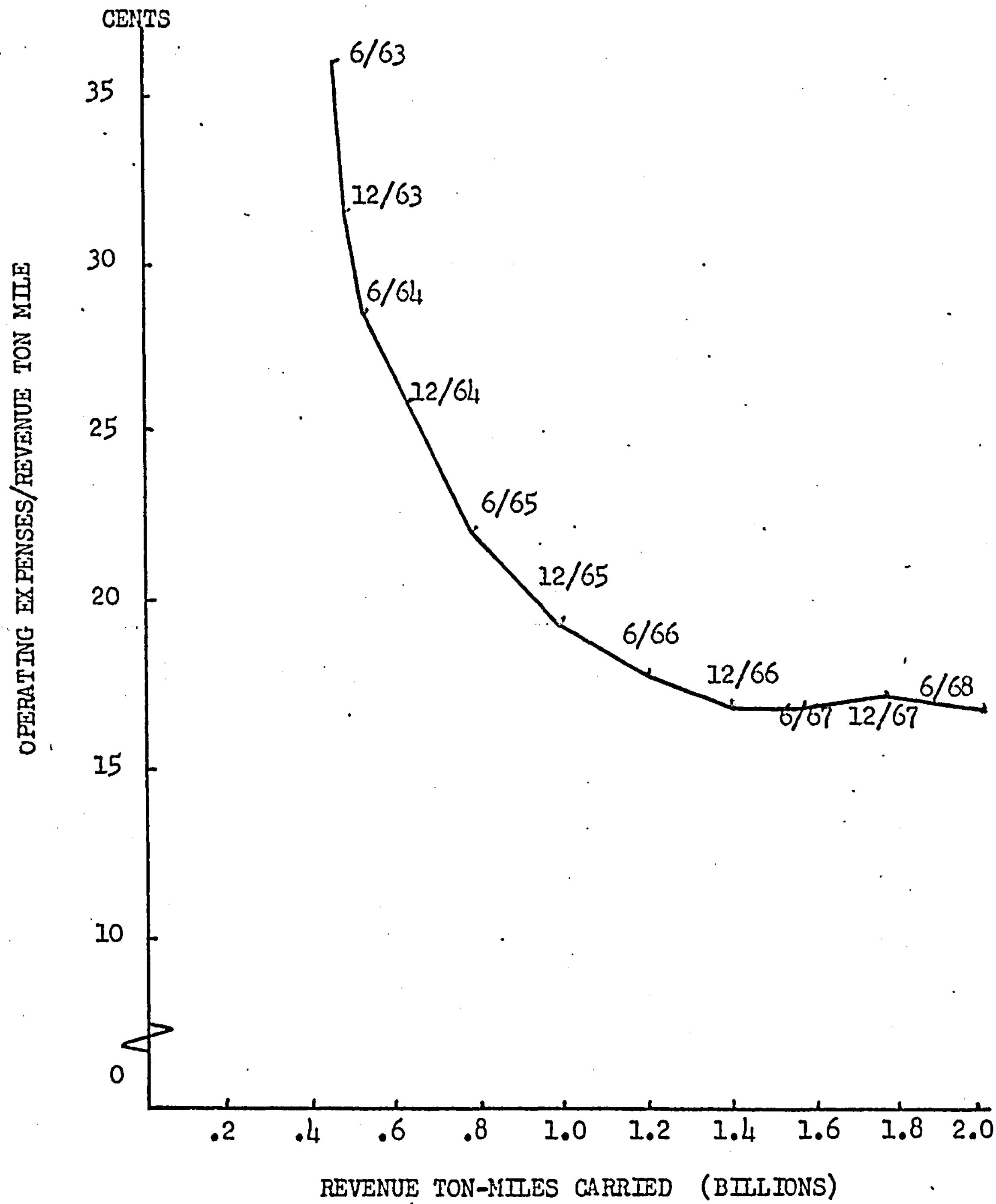

Figure 21. Operating Expenses/Revenue Ton-Mile and the Total Revenue Ton-Miles Carried by the Industry by Year

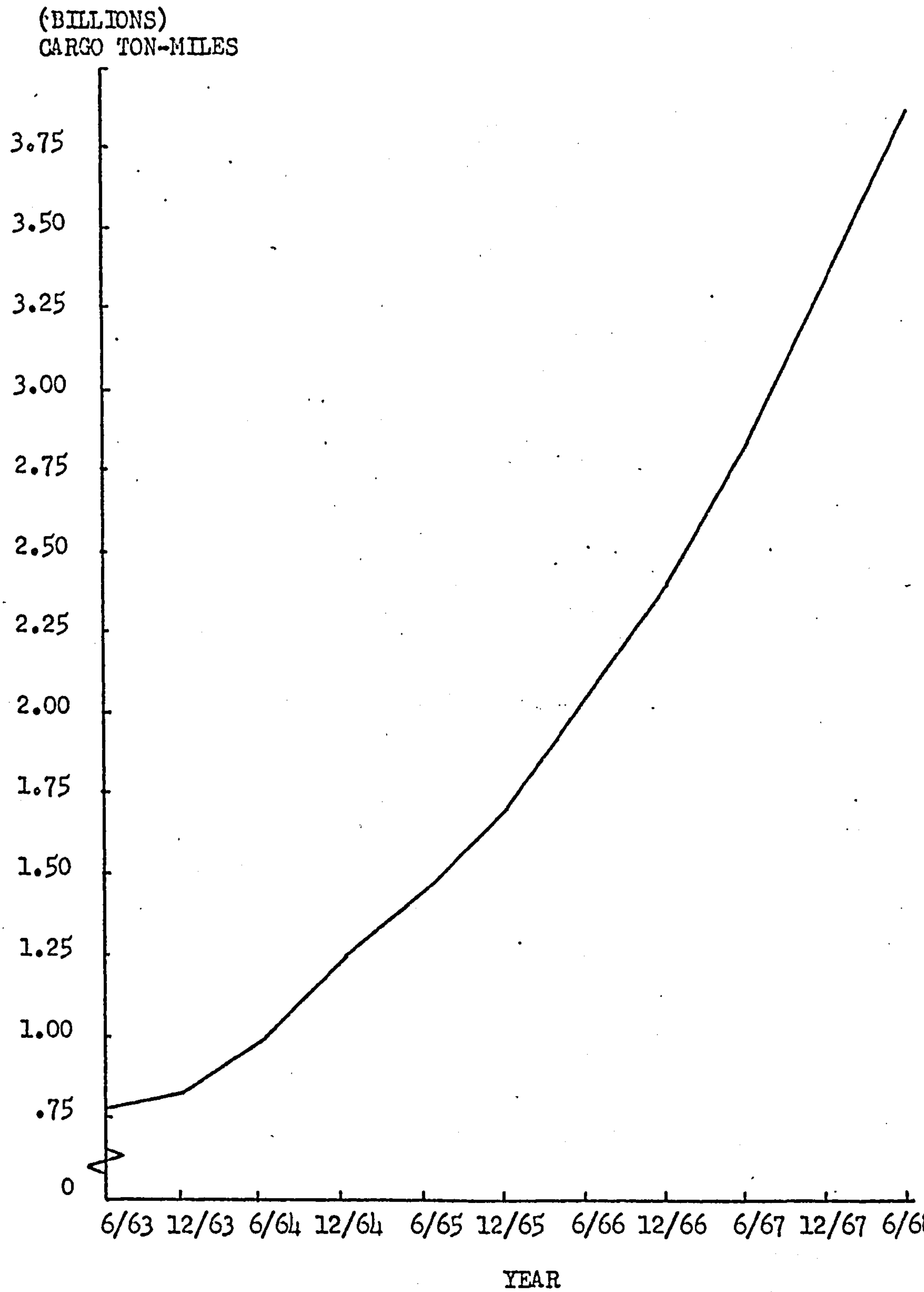

Figure 22. Available Ton-Miles for the Industry: All-Cargo Flights

potential costs. Load factor seems to be an important factor which may cause actual costs to exceed potential costs.

The penetration of the potentially better turbine aircraft would be expected to have a pronounced effect upon both potential and actual costs realized within the industry. If it were not for the possibility of over-capacity, it would seem relatively safe to forecast lower tariff rates for the future. In full capacity operations, the L-500 and B-747's would be expected to lower operating costs per unit of cargo carried and increase net revenues. This would make lower tariff rates possible as profits tended to increase and the CAB continued to enforce the rule that domestic carriers not exceed ten per cent net returns on investments. How much rates would be reduced is hard to predict because of the effects of rising labor costs, equipment costs, and management costs. If the air carriers can improve their facilities along with the addition of the new aircraft and make equal cost reductions in indirect operating costs, then total costs could decrease slowly until they were 20 to 30 per cent lower than they are presently. The transition would be gradual since the existing fleet of aircraft would still be operating along with the new planes. As the existing aircraft are depreciated or taken out of operation, the effects of the new planes should be felt more strongly.

A Conceptual Model of the Airline Industry

In less than full capacity operations the effects of the new technology would not be as noticeable. Overcapacity seems to be a problem that plagues the domestic airlines' operations. A simple model of the airline industry may help explain how overcapacity arises and what effects it can have. The following model combines important relationships such as demand, costs, and capacity and illustrates their interaction within the carrier industry. In this model, full capacity refers to the maximum amount of service the industry can provide at a given time. The industry could meet full capacity by operating at full load factor and full utilization. Tariff rates are considered to be pre-determined in the model due to the institutional system used to establish the rate structure. In later versions of the model, it is recognized that the rate of utilization and per unit costs may be a determinant of the level of rates. For simplicity, the industry will be assumed to be composed on one large firm under one management and will be called the air carrier. The air carrier has the ability to set his capacity limit by adding or deleting aircraft and equipment. The costs to the air carrier will be considered in the framework of variable costs, fixed costs, and total costs.

Figure 23 shows the expected relationship between the air carrier's costs at a particular capacity limit.

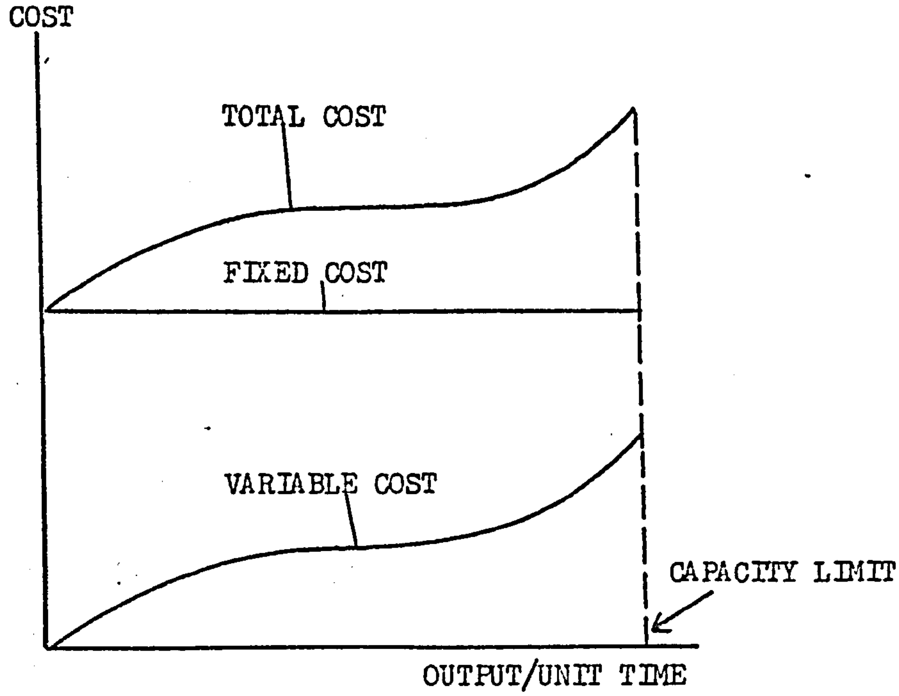

Figure 23. Airline Costs at Various Capacities

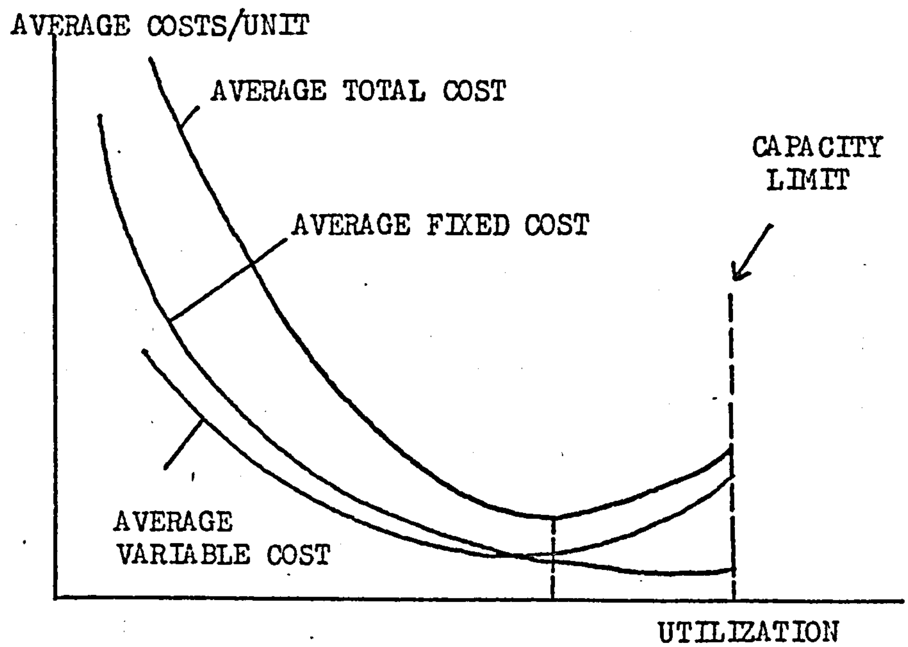

Figure 24. Average Costs at Various Utilization Levels

Fixed costs for aircraft and equipment make up a large portion of the total costs in Figure 23. Variable costs increase as output is increased, first at a decreasing rate and then at some point, the variable costs increase at an increasing rate. Average total costs can be measured as a function of output or as a function of per cent utilization of existing equipment. In either case the average cost curve will first decrease until reaching the minimum, and then increase until 100 per cent utilization is reached.

Figure 24 shows average costs as a function of utilization in which the average fixed costs appear as a rectangular hyperbola. It is assumed that for the carrier's operation up to some point of utilization of equipment there would be cost reductions, but past this level of utilization the costs would increase due to the increasing cost of management and labor. If the carrier tries to keep all planes completely full it will have to devote much extra time in scheduling the arrivals and departures of the aircraft so cargo pickups and deliveries would exactly meet the schedules. The relationship between utilization of equipment and quantity is a linear function where 100 per cent utilization of equipment is associated with the full capacity limit. The carrier determines this function as it purchases or disposes of equipment.

The Basic Air Carrier Model

Figure 25 represents the basic model described for the air carrier. Quadrant 1 of Figure 25 represents the air carrier's cost curve where average total costs are a function of utilization. This function will remain constant over all capacity limits. This assumption is that the curve represents a mix of the most efficient available aircraft, equipment, and management, and that there are no economies of scale over the relevant capacity limit ranges in the model. It would be possible to represent less efficient mixes of equipment, aircraft, and management in this quadrant, but these curves would lie above the curve shown in quadrant 1. Quadrant 2 represents the demand function for the carrier's services and the cost curve as a function of quantity, given a particular capacity size limit (Q1). It is important to understand that the cost curve in quadrant 2 relates to one capacity limit (Q1), while the demand curve in quadrant 2 is independent of the capacity. The cost curve in quadrant 2 can be found at any capacity limit along the quantity axis, given the basic cost function in quadrant 1. This is done by tracing through quadrants 3, 4, and 1 to determine the relevant cost at each quantity of service demanded.

Quadrant 3 is the quantity-utilization function which relates utilization levels to the quantities of service demanded. The slope of this line is determined by

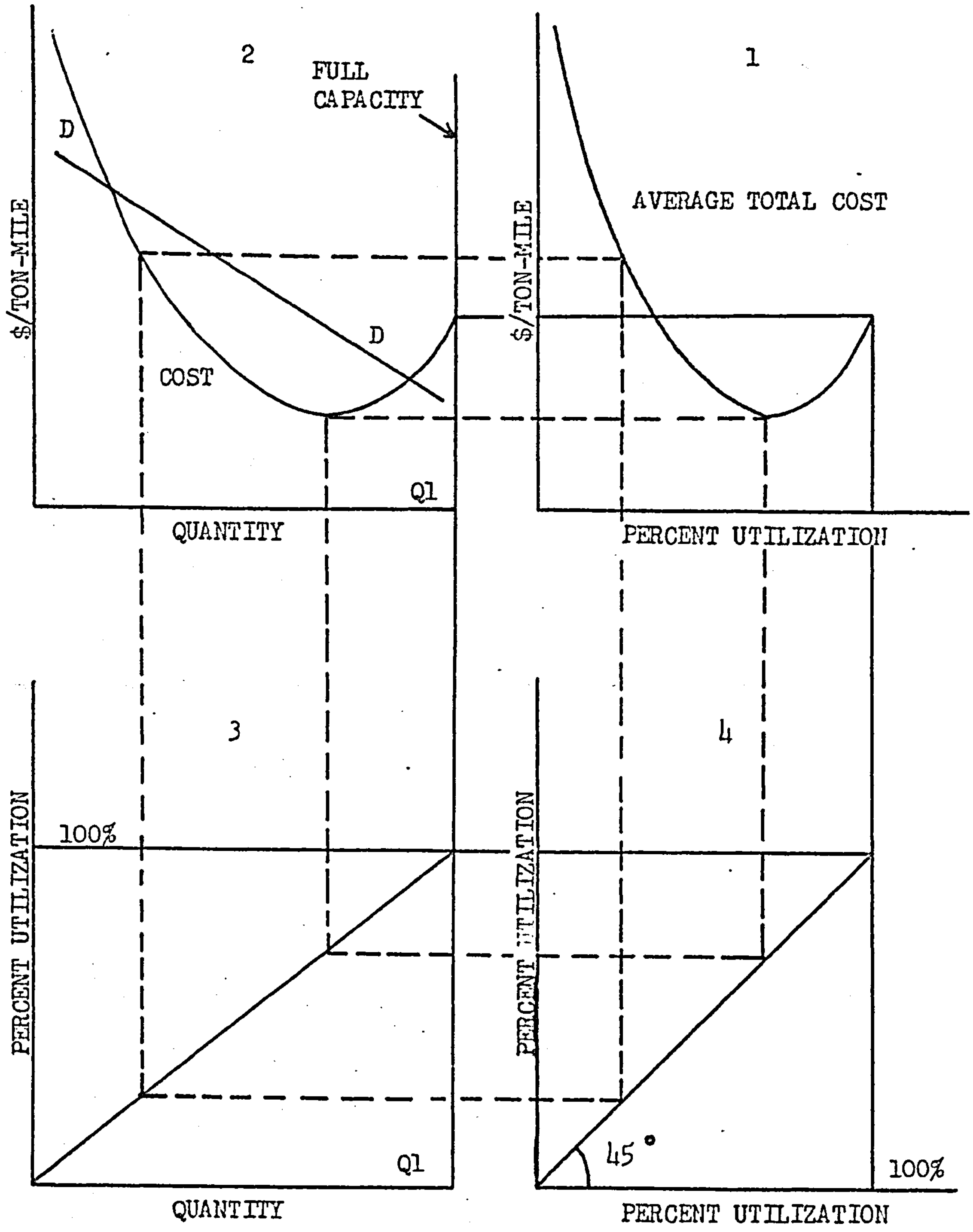

Figure 25. The Basic Air Carrier Model

the quantity of equipment that the airline industry has in service. If the quantity of equipment increases, this function in quadrant 3 will rotate about the origin and become more nearly horizontal, and with no change in the quantity of services demanded, per cent of utilization will fall.

Quadrant 4, with utilization on both axes, is a 45 degree line. It is used to translate utilization from being measured in a vertical direction as it is in quadrant 3 to the horizontal as it is in quadrant 1.

It is an important assumption in this model that the airlines use all of the equipment that they own rather than letting some stand idle in order to keep utilization rates high. The fact that the airlines have operated in recent years with average utilization rates of 50 to 60 per cent strongly supports the assumption that they do use all of the equipment they own.

Applications of the Air Carrier Model

In Figure 26 the model can be used to show the effects of tariff rates. At the tariff rate R1, the quantity of services demanded is Q1. At this level of demand, the level of costs will be at the minimum cost level C1 in quadrant 1. The profit would be equal to the area (R1-C1)Q1 in quadrant 2. Maximum profit occurs at the point where marginal cost equals marginal revenue, not

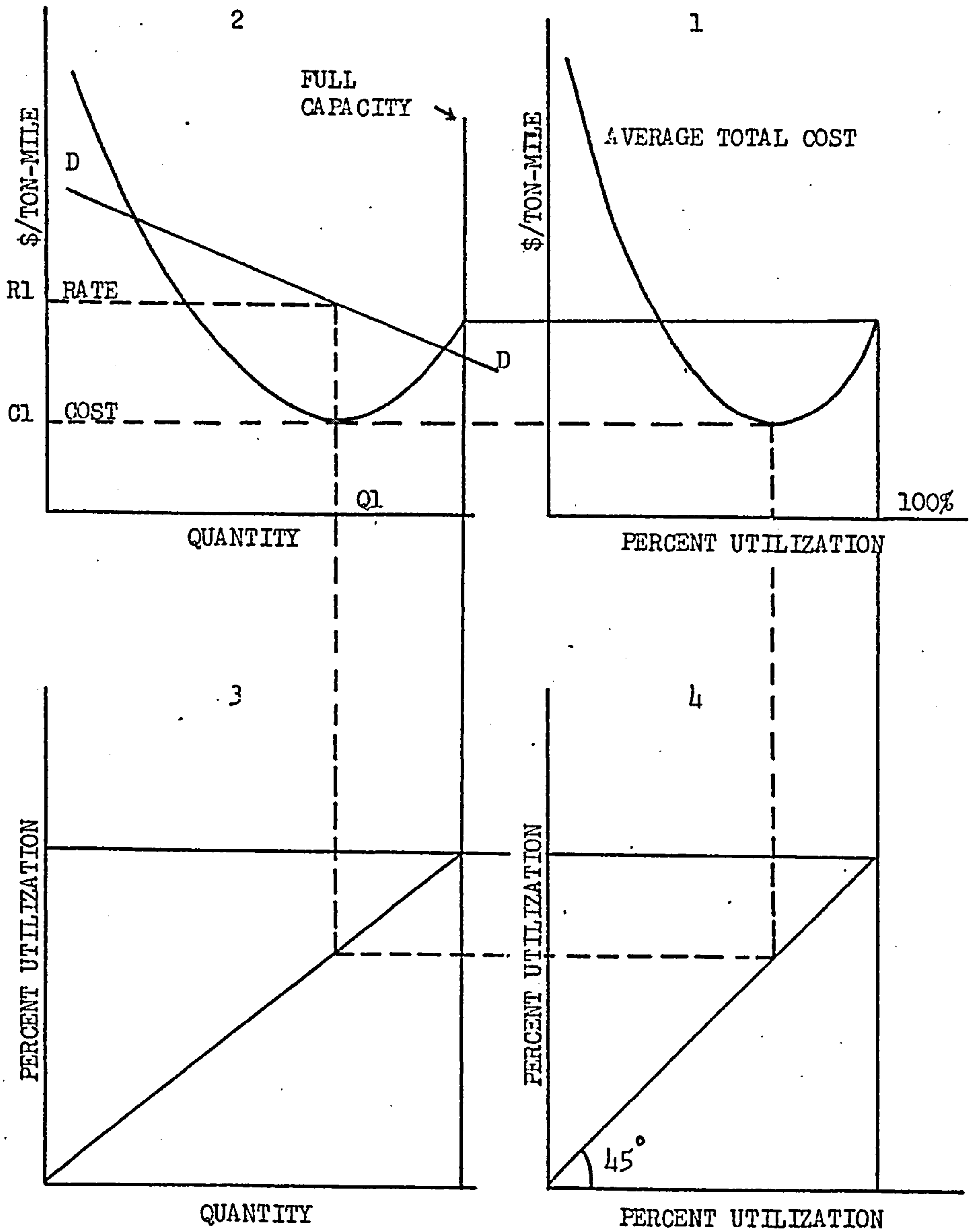

Figure 26. The Air Carrier Model: The Effects of the Tariff Rate

illustrated in the model, or where the area (Rm-Cm)Qm is maximum. If the cost curve in quadrant 2 were above the demand curve for all levels of quantity, the carrier would operate at a loss, regardless of the level of tariffs, and the best the carrier could do would be to minimize his losses.

In Figure 27 a situation is shown where the air carrier is operating at a loss with a capacity of C1. In quadrant 2 the carrier's cost curve CC1 lies above the demand function DD. The rate may be set to minimize losses, but there is no profitable solution at this level of capacity. At capacity C2 the cost curve CC2 lies below the demand curve and the carrier will profit at any rate level between R1 and R2. The capacity is important in determining if the air carrier has a profitable situation. The air carrier cannot achieve any net income if capacity is too large.

Figure 28 shows the effects on costs and profitability of replacing a fleet of 707 size planes with a fleet of 747 size planes with the same total capacity. In quadrant 1 the relevant cost-utilization function shows the reduced costs made possible by the B-747's. In quadrant 2 the cost-quantity function and the demand curve are illustrated. The B-707's would be unprofitable at any rate below that giving U2 per cent utilization rate of the fleet. The B-747's would still profit at rates giving as

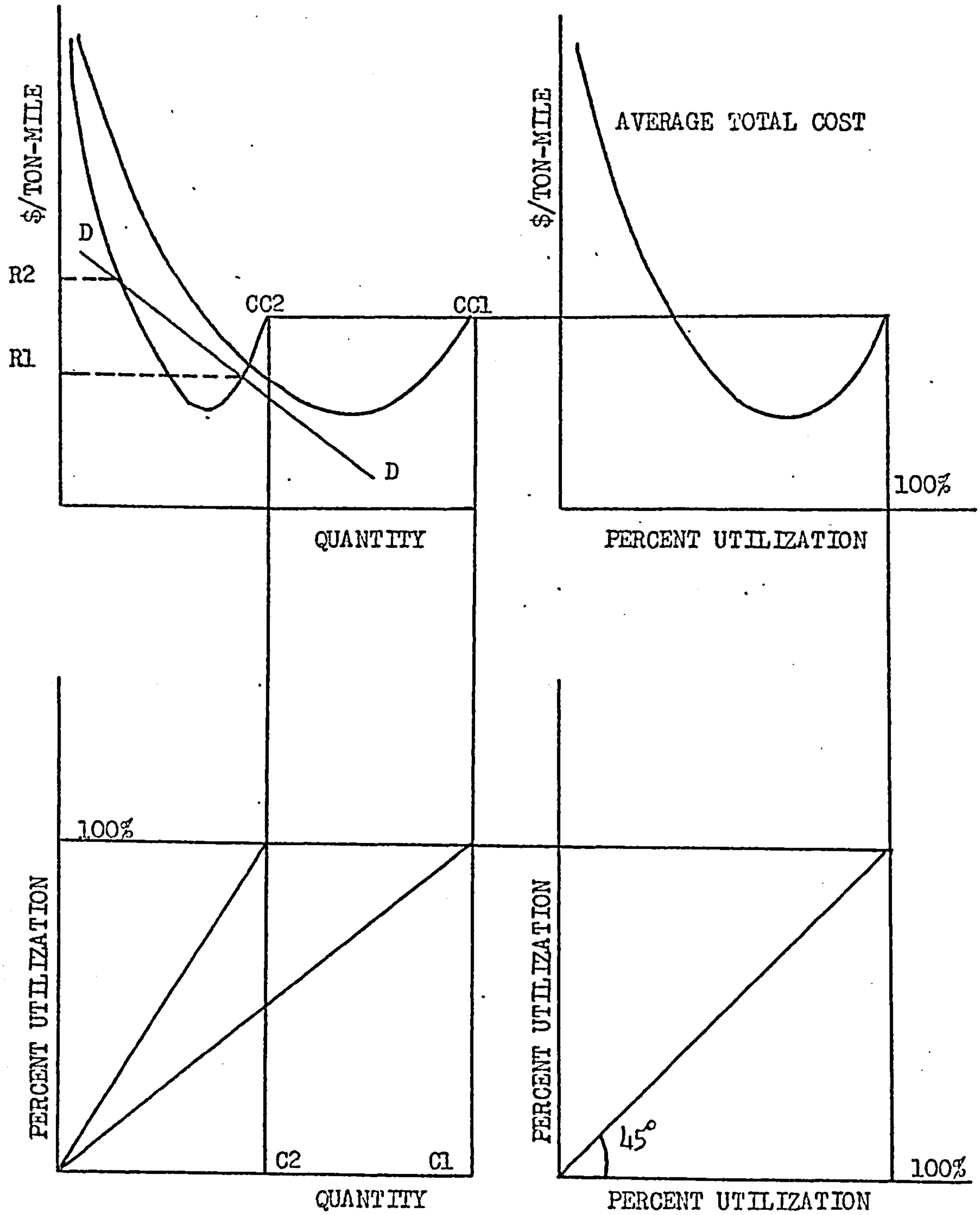

Figure 27. The Air Carrier Model: The Effect of Two Different Capacities at a Given Level of Demand

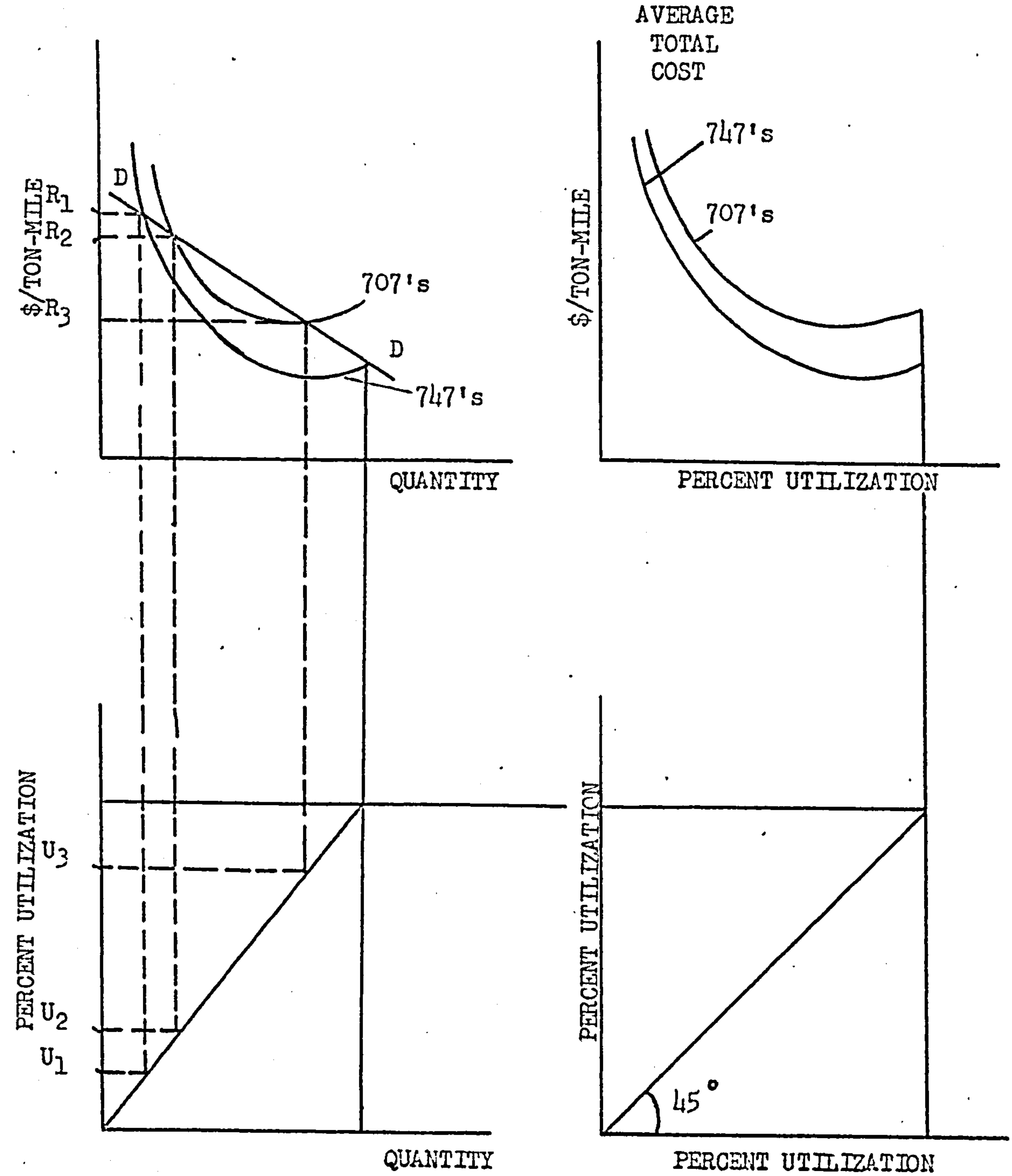

Figure 28. The Air Carrier Model: The Effects of Replacing a 707 Fleet With a 747 Fleet

low as U1 per cent utilization. The level at which the B-747's will break even will therefore be lower than it would be for the B-707's.[1] At rates which give more than U3 per cent utilization the B-707's become unprofitable due to rising costs, while the B-747's show profits up to full 100 per cent utilization. However, because the new B-747's will add substantially to capacity, it is not obvious that they will increase airline profits in the first few years of service. The quantity of service demanded would be divided between many B-707 and B-747's in operation. The effects of the B-747's on profits will depend greatly on how much capacity is increased and how demand responds over time. The air carrier could lower rates if he could lower the cost curve in quadrant 1 without at the same time increasing capacity too greatly. These diagrams suggest that the profit maximizing price for services would be lower for the larger planes.

To chart the future condition of the air carriers it would be necessary to know the cost-utilization function for a mixed fleet of aircraft that included both B-747 and B-707 size planes. Also needed is the demand curve for the

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1. In actual practice neither of the planes will likely be profitable at such low levels of utilization, but the intent here is to show why the break-even level will be reached at a lower level of utilization for the larger plane.

future period. Even as the B-747 size planes become operational, existing aircraft will still be operating.

Figure 29 depicts the possible conditions of the future of the air carrier. The costs of the combination fleet in quadrant 1 gives the cost-quantity function shown in quadrant 2. The three demand functions shown give entirely different effects. D1D1 would create a profitable situation for the carrier. D2D2 shows the situation where the carrier could profit but the rate would be crucial. Only rates between R1 and R2 would create profits, and all other rates would result in losses. D3D3 shows a situation where the carrier has over capacity so great that no profit is possible. Unless the demand curve D3D3 shifted outward the carrier could not earn a profit by operating with this capacity.

This model has been developed to help in identifying the important variables and to illustrate how they may be interrelated. Capacity can make the difference between profit or loss to the airlines. Tariff rates are an important factor in determining what the carrier's average cost will be. Either rates too high or rates too low can increase the carrier's realized costs due to the effect of utilization of equipment. The addition of the newer planes like the B-747 and L-500 should slowly lower the carrier's cost-utilization function of quadrant 1. In Figure 28 it

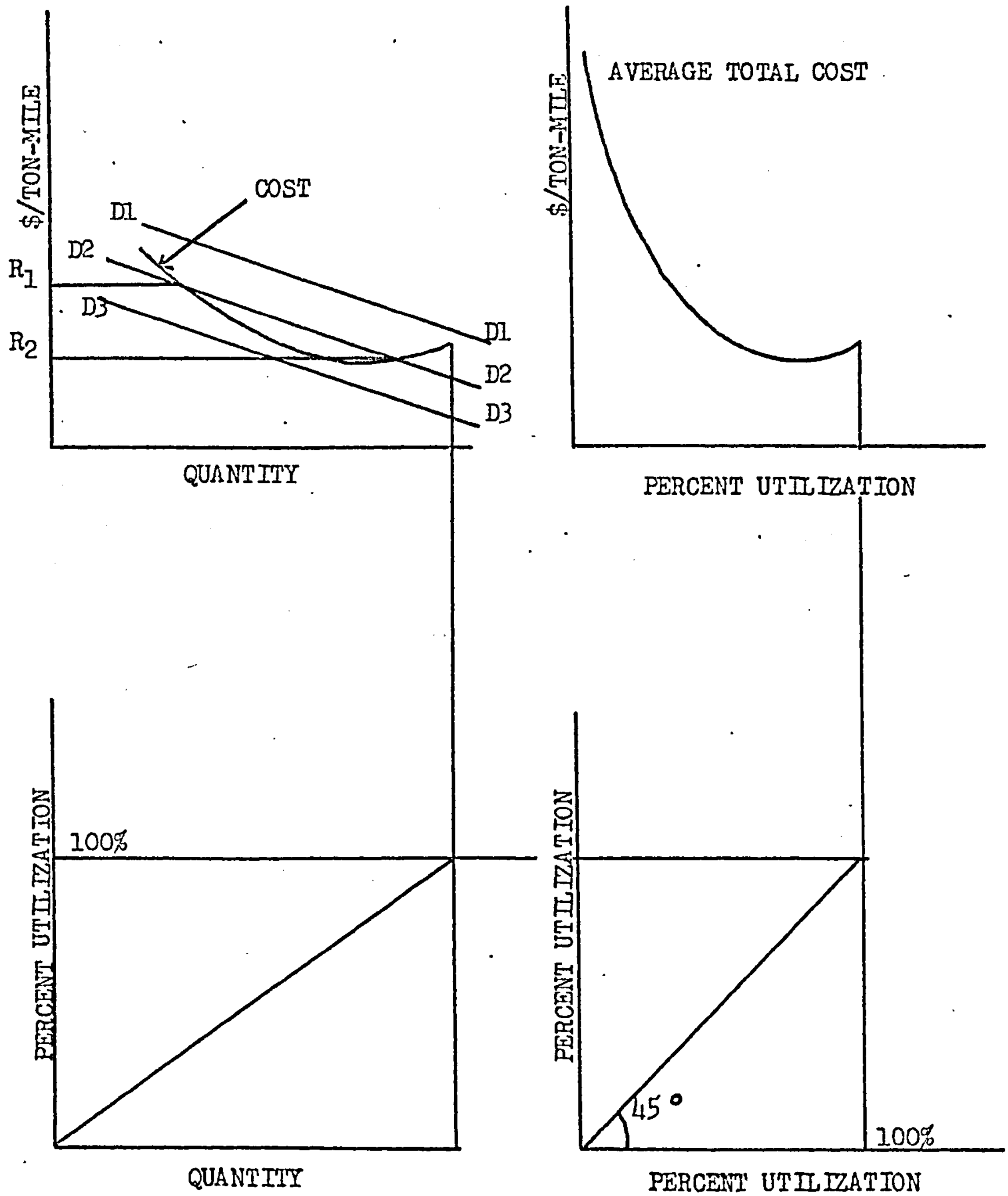

Figure 29. The Air Carrier Model: The Effect of Three Different Levels of Demand Upon the Air Carrier

was shown that with a lower cost curve in quadrant 1 the carrier could effectively lower its tariff rates.

In conclusion, the effects of the purchase of the larger planes like the B-747 and the L-500 will depend on the demand for services and the rate of increase in overall capacity. There are good indications that the demand for air carrier services will continue to increase, especially due to the growth of the economy over the next decade. As the air carriers lower rates the air transportation mode becomes more and more of a substitute for surface modes, and as a result, the demand curve becomes more elastic as this occurs. With a decrease in rates, the air carriers can expect larger percentage increases in the amount of services demanded. There will likely be a trend toward lower rates relative to the competing modes of transportation during the next few years. If demand increases as expected, the capacity problem would not be any more a problem than it is today. Although the carriers might not be able to realize the full advantages of the more efficient B-747 and L-500, the costs could be decreased somewhat as the industry adjusts to the problems of the 1970's. If capacity problems were entirely eliminated through large increases in demand, the carriers could fully realize the 20 to 30 per cent lower costs of operation, and tariff rates would likely decrease slowly along with the adoption of new, more efficient equipment.

CHAPTER IV

MARKETING FRESH PRODUCTS

The marketing system for fruits and vegetables has features that will affect the potential for air transport to fit into the existing system. Also, some changes in either the air cargo industry or the fresh produce markets might facilitate the development of shipment and marketing of fresh products by air. For Arizona the largest crop fitting the perishables group is lettuce. Lettuce receives a large proportion of the emphasis in this study because of the size and importance of lettuce as an Arizona crop, and because there were readily available data for the lettuce production and marketing in Arizona as well as for California. Also, several shippers and lettuce buyers have experimented with air shipment of lettuce from California. Many of the things learned by the lettuce shippers should be useful in assessing the potential for air shipment of Arizona fresh products.

One of the underlying factors which shapes and determines the marketing processes for fresh products is the inherent perishability which exists in varying degrees for practically all food products. Adding to this is the characteristically concentrated production of the fresh products, especially in the colder months when California, Arizona, New Mexico, Mexico, Texas, and Florida become our major production centers for fresh fruits and vegetables. This concentration of the major production areas in the United States fresh produce market is the basis for the large and well defined distribution system. In order to sell large quantities of a product which has a concentrated production area the product has to be transported to the consumers who are widely dispersed. In the United States, the major population centers are located away from these production areas. Among the alternative modes of transportation available, there appears to be a direct relationship between speed and cost. These factors form the basis for the problems of selecting and designing transportation systems for horticultural products.

The major modes of commercial transport for agricultural products are truck, rail, ship, barge, and airplane. There are various sub types within these categories such as combination truck and rail shipment, which is commonly known as "piggyback." The costs to the shipper for shipping commodities is dependent on several things, especially the product shipped, the mode or modes of transport used, and the distance over which the product is being shipped. In the past, the shippers in Arizona have relied on truck and rail shipping almost entirely. Therefore, within Arizona the basic competition against the use of air cargo are the trucking and rail industries. After a commodity leaves Arizona it is sometimes transferred to ship for transport to Europe or Japan.

Recently, several of the airline companies have stressed the total cost concept of shipping which includes all costs related to distribution of the products such as inventory holding costs, actual shipping costs, loss and damage costs incurred during distribution, and any other relevant cost incurred during distribution. In some situations the higher costs of shipping by air will be offset by reduced costs of holding inventory, reduced costs of loss and damage, and other savings. Production of lettuce and various other fresh fruits and vegetables simply cannot be changed very much after the crop has been planted and the possibilities for storage are very limited. The main considerations in distributing fresh products, therefore, are the time and costs involved in shipping by various modes. Time and quality loss are usually directly related for perishable products. Because of this, the gains a shipper can make in reduced costs from shipping by a slower mode may be offset by the losses he incurs due to the increased quality deterioration during shipment. In comparing different modes of shipment from Arizona the relative direct shipping costs and time costs must be identified.

The Shipping Costs and the Time Involved by Various Modes

The data for comparison of actual shipping costs of truck, rail, piggyback, and air shipment were gathered during personal interviews with lettuce shippers of the Salinas, California area in September 1969. Salinas, the hub of the Western Lettuce industry, is the largest single lettuce-producing area in the United States. Many Arizona and California shipping operations have home offices in Salinas. It is assumed that the relative costs by mode of shipment of lettuce and other fresh produce from Arizona would be similar to the costs of shipping from California.

The costs and time data presented in Table 5 were computed on the basis of shipping iceberg lettuce from Salinas, California to the Huntspoint market in New York City by the various modes. The costs of truck shipments varied from 3.21 to 3.59 dollars per hundred pounds, depending on the number of cartons per load and the average weight per carton. The total shipping costs for a truck load with a maximum load of 42,000 pounds was given as $1,350. Truck shipments arrived 85 to 90 hours after leaving Salinas or on the fifth morning.

In piggyback shipments the lettuce was loaded on refrigerated truck vans, and two vans were hauled on a rail flat car. At some prearranged destination the vans would be de-railed and then hauled to the buyer via highway

Table 5. Shipping Costs for Lettuce: Salinas, California to New York City

Mode	No. Cartons Per Load	Ave. Carton Weight	Total Cost	Cost Per Hundred	Average Time Arrived
					hrs.
Truck	800	47	1,350.00	3.59	85-90
(42,000 lb. Load)	880	47	1,350.00	3.26	85-90
	1,050	40	1,350.00	3.21	85-90
Piggy Back	1,600	47	1,786.00	2.31	155
(2-42,000 Vans.	2,100	40	1,786.00	2.13	155
Refrigerated)					
Rail	1,064	47	1,160.12	2.32	168
(40' Refrigerated Car)					
		Refrigeration Charge		.20	
				2.52	
Air				8.30	8
(2,000# Minimum Shipment)					
	Charge for pickup and delivery			1.50	
				9.80	

Source: Data gathered during personal interviews with lettuce shippers of the Salinas, California area in September 1969.

truck by the rail company. The costs quoted were based on the shipper's supplying truck vans for the railroad to haul. By this method, the standard charge was $1,786 for two 42,000 pound refrigerated vans, which gives an average per hundred weight cost of 2.13 to 2.31 dollars. These shipments would arrive on an average of 155 hours or on the seventh morning after leaving Salinas.

Rail rates were based on standard rates per car load of $1,160.12 for a 40 foot refrigerated car and $1,475.12 for a 50 foot refrigerated car. These rates exclude refrigeration which averages 20 cents per hundred pounds. Based on a 40 foot car with a 1,064 carton load of 47 pounds average weight cartons, the rate was $2.52 per hundred. The arrival time for rail shipments was about 168 hours, or arrival on the eighth morning.

The air rate for iceberg lettuce shipped from the San Francisco airport to the New York Kennedy airport was 8.30 dollars per hundred based on a 2,000 pound minimum shipment. This did not include the shipper's cost of delivery and pick up at the two airports which cost approximately $1.50 per hundred weight. Based on these figures the air shipping cost totaled 9.80 dollars per hundred. The time for air shipments averaged eight hours, or in practice, overnight delivery. The shipper in Salinas first moved the lettuce by truck to the San Francisco airport for loading, then when the lettuce reached New York it had to be picked up and hauled to the food buyer's outlet. Air shipments are not normally refrigerated while they are in transit on the plane. This could lead to problems, but the speed of delivery is such that this should probably not be considered a serious detriment to air shipment. But the problem of spoilage is ever present in unrefrigerated lots of fresh produce and cannot be completely dismissed.

Cost and transit times for each of the modes may be expected to vary to some extent. The number of cartons loaded into either the rail cars or the truck vans certainly does cause variations in the cost per pound. The air rates are less variable as far as actual transit costs are concerned since the rates are on a per pound basis. The extra handling charges associated with air shipments would be variable, and dependent on several factors such as distance from the airports. The cost of air shipment is about three to four and one-half times higher than the cost of rail, truck, or piggyback shipment.

The Distribution of Traffic Between Rail and Truck Modes

Rail and piggyback rates were the lowest rates for shipment to the New York market. Also, rail is by far the major mode of transportation used for California and Arizona lettuce shipped to New York City. For the calendar year 1968, the rail unloads of California lettuce in New

York were 4,137 cars (Table 6). The rail unloads of Arizona lettuce for this year were 1,322 cars. Lettuce truck unloads in New York City during the calendar year 1968 were 252 and 85 cars respectively for California and Arizona. Rail has the advantage in longer distances which gives it this large share of the Eastern market shipment. Air shipments are not reported in the Arizona Market News Service reports because they have not been significant in volume.

In other domestic markets across the United States, lettuce is received by rail, truck, and piggyback also. Table 6 shows the truck and rail unloads of California and Arizona lettuce during the 1968 calendar year for various United States and Canadian market centers. Piggyback would be included in both the truck and rail figures since some piggyback loads are received in the city on the rail car, and some are received by truck after being deramped from the rail car at another location. The table has been arranged so that cities of one part of the United States are grouped together.

Rail is the predominant mode in the Eastern markets with a much larger share of the total than truck shipment. In the western states there are more truck than rail shipments. Chicago, Illinois seems to have an abnormally high proportion of rail shipments, but this is probably because rail routes to the eastern cities go through Chicago.

Table 6. Lettuce Rail and Truck Unloads During Calendar Year 1968 in 42 Major Markets

	Rail		Truck	
	Arizona	California	Arizona	California
New York, N. Y.	1,322	4,137	85	252
Albany, N. Y.	95	209	7	38
Buffalo, N. Y.	249	439	5	6
Baltimore, Md.	305	772	13	27
Boston, Mass.	611	1,641	24	55
Washington, D. C.	292	528	29	98
Philadelphia, Pa.	771	1,682	27	76
Pittsburg, Pa.	399	926	47	120
Providence, R. I.	57	134	3	1
Montreal, Que.	374	631	--	--
Toronto, Ont.	451	592	--	--
Ottawa, Ont.	52	67	3	11
Birmingham, Ala.	15	132	92	478
Atlanta, Ga.	38	248	222	709
Columbia, S. C.	55	172	50	342
Memphis, Tenn.	10	30	34	173
Nashville, Tenn.	39	169	7	121
Miami, Fla.	76	221	73	432
New Orleans, La.	48	216	193	398
Chicago, Ill.	1,007	2,923	65	132
Cincinnati, Ohio	221	768	9	116
Cleveland, Ohio	352	1,233	65	243
Detroit, Mich.	586	1,689	27	167
Indianapolis, Ind.	102	290	17	344
Louisville, Ky.	69	289	65	117
Milwaukee, Wisc.	132	301	24	64
Minneapolis, Minn.	204	683	35	335
San Antonio, Texas	24	387	161	667

Table 6.--Continued

Fort Worth, Texas		12	103	337
Houston, Texas	103	498	155	372
Dallas, Texas	21	184	350	806
St. Louis, Mo.	250	1,087	69	324
Kansas City, Mo.	5	47	256	642
Wichita, Kan.	2	8	17	56
Los Angeles, Calif.	--	--	668	9,454
San Francisco, Calif.	--	--	337	4,186
Denver, Colo.	--	179	253	1,282
Seattle, Wash.	4	94	15	1,472
Salt Lake City, Utah	--	14	28	625
Portland, Oregon	14	179	87	849
Vancouver, B. C.	9	126	4	346
Winnipeg, Man.	42	169	--	78

Source: Table 19 and 20 from United States Department of Agriculture, Federal-State Market News Service (1969).

Also, the time by rail to Chicago is fairly competitive with truck shipment times. Rail shipping is not used within California itself, and bordering states have low percentages of rail shipment.

On the whole, rail, piggyback, and truck shipping are highly competitive. Most shippers use the modes in varying proportions depending on various conditions of the market. The buyer may specify what type of transportation is to be used when the product is sold at the shipping point. Availability of rail cars or truck vans may have a bearing on the share each mode receives. Also important would be the occurrence of labor strikes which could affect certain modes. A rail strike could stop most or all of the commodities from moving by rail and put a heavy amount of traffic on the truck or air routes. Trucking strikes are also possible, but there are independent truckers who would be willing to work through a Teamster strike if they were able to load and unload unmolested. Cut flowers and strawberries would lose some of their domestic and most of their foreign markets during an airline strike.

Climatic conditions and the accessibility of the market affect the mode of transportation used. During the winter months many areas can be unaccessible by surface and/or air modes of transport due to weather conditions. The existence of good highways and railroads is necessary before truck and rail shipments can be relied upon.

Foreign markets are accessible only by sea or air transport, both of which are dependent on weather and the availability of sea and airports near the markets.

The USDA study of interstate hauling of California-Arizona produce has the following summary which is in agreement with the conclusions reached by the author in regard to the competitiveness of transportation by truck and rail.

> The extent to which rail and motor carriers are used for out-of-state shipments of California-Arizona fresh produce depends on their ability to provide transportation commensurate with the needs of fruit and vegetable handlers. Rates and service features made by railroads and truckers favor each carrier for different types of shipments. Trucks are cheaper for short-haul traffic and, except for part loads, railroads charge less for shipments moving the longer distances. Since the regions of low population closer to California and Arizona do not require as much fresh produce as the more populated regions farther away, these differences in transportation rates have a direct bearing on the degree in which both carriers share in the outbound traffic. However, demand for rail or truck transportation rests on the functional utility of the carrier to the user, and does not necessarily reflect economies in rates. The quality and type of service offered play an important role in attracting interstate shipments regardless of the price asked for the hauls (United States Department of Agriculture, Economic Research Service, 1964, p. iv).

The shipping costs presented in Table 5 of this chapter and the related material are very important to the shipping decision but do not include all of the time related costs that affect the shipper. Time related costs to the Arizona shipper of horticultural products include inventory holding costs, costs due to the effects of price risk, and costs of quality losses incurred during shipment. The nature of these costs prohibits an accurate, thorough listing by mode.

Inventory-Holding Costs

The inventory costs arise due to the opportunity costs of the capital the shipper has tied up in the product he is shipping. The low value per unit reduces the importance of this cost. For example, the cost of capital per carton of lettuce is less than one cent if the lettuce is owned ten days. This figure is based on the following data:

Lettuce costs per carton are given as $2.75 f.o.b.,

Interest rate is ten per cent,

I is the daily interest cost per carton,

I = $2.75 x .10 x 1/360 = $0.00076,

One day's cost is = .076 cents per carton,

Ten day's cost is = .76 cents per carton.

These data illustrate that inventory costs are too small to become an important consideration affecting choice of mode.

Price Risk

The variability of wholesale lettuce prices and f.o.b. lettuce prices causes the price risk which exists for the shipper. A lettuce shipper who buys lettuce from the producer and then sells several days later may gain or lose money depending on the price movements during the time he owns the lettuce. It seems that by decreasing the time period over which the shipper owns lettuce he would reduce the chance of a large price change on lettuce. The question is whether this is a relevant factor in the long run. The producer-shipper operating in today's market can usually depend on the average prices being such that the margin between f.o.b. and wholesale prices is on the average fairly uniform and predictable if the firm ships large quantities distributed over most of the year. The shipper is not interested in speculation, but in handling a large volume and netting at least the normal rate of return. It is doubtful that a large shipper could increase his margin in the long run by using air transportation in lieu of rail or truck transportation because he will be selling lettuce continuously regardless of how it is shipped. Also, the advantage now held by the rail shipper during periods of rising prices would be lost.

If the retailers were to buy directly from the produce shipper, taking possession of the produce several days before it reaches the market, he would be taking additional price risk. In the long run, the produce market seems to be such that price risk to individual large shippers or direct retail purchasers is not a great factor. The benefits of any reduced price risk gained by switching to air cargo would seem to be of minor importance to the current problem.

While nearly all of a commodity is still shipped by rail and truck, there may be brief periods during which the markets are in unusually short supply and individual shippers may benefit by temporarily using air shipment to get their product onto the market before rail and truck shipments have succeeded in bringing the market to more normal equilibrium. Also, at the beginning of a shipping season for some commodities an individual shipper may be able to ship his product to market by air and arrive several days before the first rail or truck shipment.

Quality Related Costs

Quality related costs are potentially greater than either the inventory or price risk related costs. Damages and losses in quality account for several million dollars of losses every year to people within the perishables marketing system. Most of this cost must be ultimately borne by farmers and consumers. The shipper using air transport would gain the ability to reduce the losses in damaged and spoiled shipments in many commodities. As long as the bulk of the commodity continued to move by rail and truck, the air shipper would be in a position to capture the gains from reduced losses.

Although the present rail and truck rates do reflect some of the cost of damage, loss, and spoilage incurred by these modes, the shipper in many cases must bear the cost of these losses. Delays in rail transit are a common source of complaint, and often there is no compensation to the shipper for the loss in shipment. It would seem that a shipper could save from five to ten per cent in damage losses if he were to switch to air transport of perishables. In overseas shipment the loss is often near 10 per cent due to the time and handling involved. Air freight losses on the same shipment might be only one or two per cent. Because of this the air transport costs can be discounted, which makes them more competitive with surface rates and costs. Another basis for discounting the high air tariff would be premium prices received for the air shipped products.

Technology Within the Perishables Marketing System

The development of several forms of technology will play an important part in the 1970's. The container concept for example has received much attention in the transportation of commodities by air. Ground handling of cargo is a significant portion of total costs. By containerizing cargo the carrier can speed loading of goods and greatly reduce labor costs. In handling perishable commodities by containers it is important to note that containers increase the weight of unsaleable material that is hauled. For low value density goods that are on the threshold of being too low valued to be air shipped, containers may not be any benefit to the air shipper in terms of costs. In lettuce for instance, the cheapest method of shipping by air may be some form of bulk shipment that can be quickly transferred from truck to plane. A load of lettuce shipped in a container such as the intermodal 8 x 8 x 40 foot container that can be hauled by truck and transferred to the plane would likely be more costly per pound of lettuce than a bulk load because of the added tare weight. Also, there is the problem of returning the container to a place where it can be loaded with produce again. Unless there is an equal amount of back haul by container the containers may have to be returned empty. Container programs for air shipment of produce will become more feasible as the rate differential between air and surface diminishes and added weight of containers, therefore, becomes less costly to the shipper.

Another innovation in the marketing of fresh products is the pre-processing of items before they are shipped. Much of the tonnage hauled by our carriers at present is ultimately thrown away by the housewife. A large portion of the total transportation bill is the cost of hauling this waste material. Many items such as citrus or melons can have inedible portions removed and be packaged in plastic bags by growers or shippers and shipped by air transport. The effect of this process is to increase the value density of the product, thereby making it a more likely candidate for air shipment. On items that are harvested as vine or field ripened and pre-processed in this manner the shelf life of the item may be too short to be feasibly shipped by rail or truck. Therefore, the increased cost of transporting by air is at least partially offset by the increased value density of the product, and it may not be possible to ship the pre-processed product by surface means.

New technology and improvements in the industry can also work against air transport growth in the perishables field. The completion of major segments of the interstate highway system will increase the ease of truck movement during the 1970's. Bulk refrigerated rail cars have helped the railroad fight increasing costs. Also, work on controlled atmosphere has led to improvement in the refrigeration and storage capabilities of rail and truck containers. The longer transit time is not as harmful under atmospherically controlled conditions, and fresher products can be delivered with this method. Innovations such as these will reduce the time-related advantages of the air carriers, but in the case of atmospheric control, the truck or rail shipping cost is increased which would force a lower differential between surface and air rates.

New technology will likely always change the relative competitive position of various modes of transport. Technology at the present seems to favor the air carrier industry. The concept of pre-processed, fresh, field-ripened produce hauled directly by air is new to the consumer and the possibilities for new development in this area seem to be substantial.

CHAPTER V

THE AIR SHIPPING SITUATION

The Shipper and the Choice of Modes

Up to this point this thesis has shown that the new aircraft of the B-747 and L-500 class could have the potential of lowering the airlines' operating costs by 25 to 30 per cent. In this case it would be expected that air freight rates would also be lowered up to 30 per cent. Presently, we have seen that air shipping costs for lettuce are from three to four and one-half times higher than the cost of rail, truck, or piggyback shipment. Also, it seems that inventory cost reduction and price risk reduction are not very strong forces for offsetting the higher air rates. On the other hand, it seems that reductions in losses due to spoilage, loss, damage, and other related problems of shipment could be a substantial factor in offsetting the higher air rates. The effect of the above factors on the shippers' decisions of which modes to use is discussed in the following analysis.

The Product-Product Model for the Shipper in Salinas

The product-product model (Chapter II) is a good method of illustrating how the shipper would likely react to changing cost or price conditions within his markets. When two modes of transportation are compared, the costs of inputs such as lettuce and the costs of services such as providing for transportation, inventory-holding, and the incurrence of damages can be included on a single chart or diagram. The following figures and tables are used to represent a lettuce shipper in Salinas, California, faced with three alternative modes of transportation for shipping lettuce to New York City. The shipper can ship by rail, truck, or air, but he is seeking to maximize profits from his shipping operations.

One unit of Product A is 100 pounds of fresh lettuce at the Huntspoint Market in New York City air shipped from the shipper in Salinas. One unit of Product R is 100 pounds of fresh lettuce in the same market rail shipped from the shipper in Salinas. One unit of Product T is 100 pounds of fresh lettuce in the same market trucked from the shipper in Salinas. The lettuce is in 45 pound cartons with 24 heads per carton. On this basis, the cost of producing either A, R, or T would include the appropriate charges for the following: (1) the cost of the field-packed lettuce, (2) transportation and handling costs incurred for shipment, (3) the inventory-holding cost, (4) the cost of damages, and (5) the shipper's time and the use of his facilities (overhead charges).

The Cost of Procurement

The cost of 100 pounds of field picked lettuce is found by multiplying the current f.o.b. price by 2.22 (the number of 45 pound cartons per 100 pounds). In the following tables the f.o.b. prices of $2.50 and $4 per carton are used to represent prices paid for lettuce. To find the procurement cost for the lettuce, the price per 100 pounds is multiplied by the hundred-weights shipped (110 pounds = 1.1 hundred-weight).

The Shipping and Handling Costs

The shipping and handling costs for the different modes are taken from Table 5. To find the total charge for shipping and handling for a particular mode, multiply the hundred-weights that must be shipped by that mode to produce one unit of product by the shipping rate.

The Time Costs

Inventory-holding or time costs are found by taking the value of lettuce purchased for shipment at ten per cent interest for the number of days needed. Product A takes one day to reach the Huntspoint market. Product R takes ten days and Product T takes five days to reach this market. The time costs are rounded to the nearest cent in all of the following tables. If lettuce is $2.50 per carton and a 100 pound shipment takes 10 days, the cost is the following: $2.50 x 2.22 x 0.10 x 1/36 = $0.0154, or about $0.02 per 100 pounds.

The Costs of Damages

The costs of damages are difficult to assess because quality is hard to measure in lettuce as well as in many other horticultural products. The length of shelf-life, an unseen factor, may or may not affect the price received for lettuce. The shelf-life of air shipped lettuce would be nine days longer than for rail shipped lettuce. However, the length of shelf-life might not be considered if the lettuce changes hands very quickly at the retail and wholesale levels. It will be assumed here that each unit of Product A, R, or T is 100 pounds of undamaged lettuce. The lettuce is accepted as undamaged if it meets the standards set for each mode of shipment.[1]

The shipper of rail lettuce will have average losses of up to ten per cent on long distance shipping. In this model the rail shipper must ship 110 pounds of lettuce in order to produce 100 pounds of acceptable lettuce (approximately a nine per cent loss). Truck shipments generally run lower in losses. The truck shipper in this model must ship 105 pounds of lettuce in order to

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1. Well-handled rail and truck shipments can and do reach the eastern markets in good condition. A well-handled carton of lettuce will stand the normal eight to ten day shipment by rail with little or no visible loss of quality.

produce 100 pounds of acceptable lettuce (approximately a five per cent loss). The air shipper has to ship 101 pounds of lettuce in order to produce 100 pounds of acceptable lettuce (approximately a one per cent loss). With this method the costs of damages are included within the transportation costs, the costs of the raw lettuce, and the costs of time. A one per cent loss in an air shipment would cost more than a one per cent loss in a rail or truck shipment.

For A, R, or T the sum of the cost of procurement, the cost of shipping and handling, the time costs, and the damage costs equals total costs excluding (Total Costs Excluding = TCE) the cost for the shipper's time and use of his facilities. The costs for the shipper's time and use of his facilities is assumed equal per unit of A, R, and T. Therefore, once the shipper has covered the total costs for each product (TCE), he would have no preference between making one dollar above total costs (TCE) on Product A as compared to making one dollar above total costs (TCE) on Product R or T. In the short run, the shipper is likely to produce as long as he can cover these total costs (TCE) per unit. The true cost for the use of the shipping facilities is a fixed cost and would be very low on a per unit basis.

The Current Situation of the Shipper

Table 7 illustrates the total costs (TCE) of producing products A, R, and T for a shipper in Salinas, California. These costs are representative of the costs facing the Salinas shipper today at a time when the f.o.b. price of lettuce is $2.50 per carton. The costs for procurement of lettuce are shown. Due to the higher levels of damages for truck and rail shipments, the costs of procurement for these modes is higher than for air shipment. The shipping and handling costs in the second row are also based on the amount shipped. Therefore, the costs for rail shipping and handling is approximately nine per cent higher than the rail rate per hundred pounds due to the cost of damages. Time costs are quite low, and the additional time costs due to damages is insignificant.

Figure 30 graphically illustrates the relationship between air shipped lettuce and rail shipped lettuce. In lettuce shipments to New York City the rail mode has been the principal carrier (Table 6). For air shipments to take place they would have to compete against and replace mostly rail shipments and a few truck shipments. In this figure the absolute slope of the iso-cost line is equal to the ratio $R1 = \frac{Cr}{Ca} = \frac{8.90}{15.51} = 0.574$ (refer to Table 7 for Cr and Ca). The iso-revenue line with the 45 degree slope represents the condition with Pa = Pr (price offered for A = price offered for R). The position of the iso-cost line

Table 7. Costs of Producing A, R, and T With a F.O.B. Price of $2.50 per Carton With Current Air Shipping Costs

Cost	Per Unit of A		Per Unit of R		Per Unit of T	
Procurement (f.o.b. $2.50)	5.55x1.01	5.61	5.55x1.10	6.11	5.55x1.05	5.83
Shipping & Handling	9.80x1.01	9.90	2.52x1.10	2.77	3.35x1.05	3.52
Time Costs		.00		.02		.01
Total Costs Excluding the Cost for the Shipper's Time and Use of his Facilities		Ca = 15.51		Cr = 8.90		Ct = 9.36

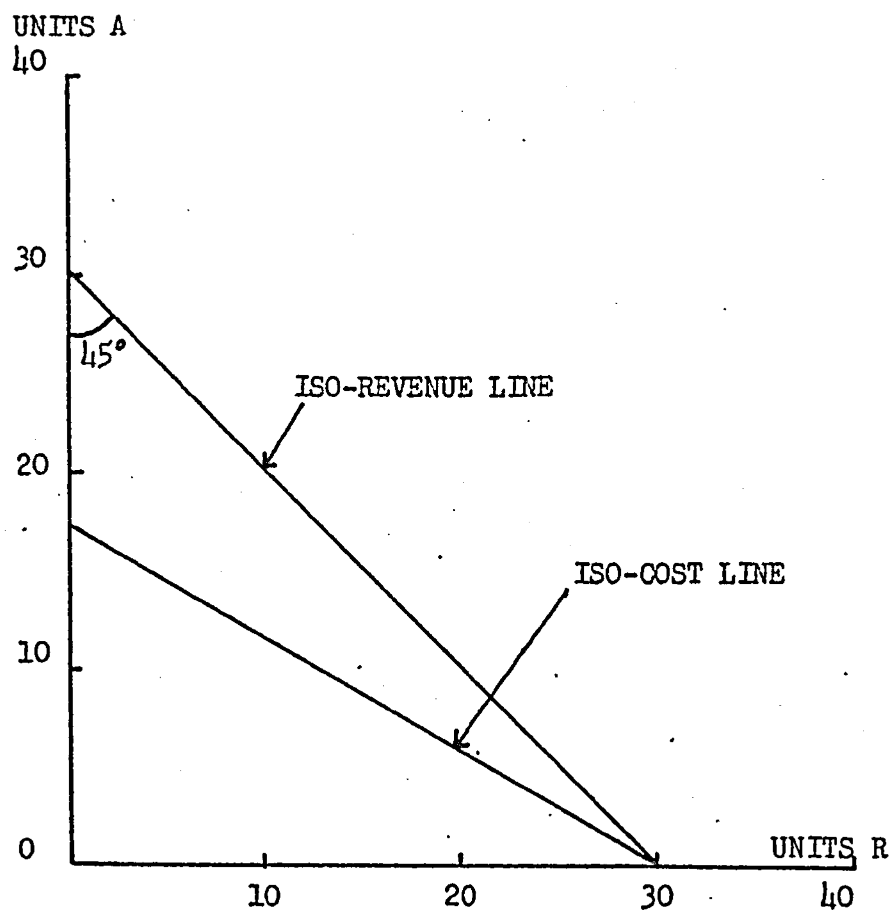

Figure 30. Product A-Product R Model for the Shipper in Salinas With a F.O.B. Price of $2.50 per Carton

is determined by the cost constraint chosen. With equal selling prices Pa = Pr the shipper would choose to produce only Product R. In order for the shipper to produce A the iso-revenue curve would have to have an absolute slope of less than or equal to the iso-cost curve.[1]

The Reduction of Air Shipping and Handling Costs

Table 8 represents the costs of producing A, R, and T with a 30 per cent reduction in air shipping and handling costs. Figure 31 graphically shows the effects of this lowered rate. The iso-cost line found in Figure 30 is drawn in Figure 31 as the dotted line, while the new iso-cost line representing the 30 per cent reduced rates is drawn as a solid line. The absolute slope of the new iso-cost line is higher because the cost of producing A is lower than in Figure 30 while the cost of producing R is the same. The absolute slope of this iso-cost line is the ratio R2 = Pr/Pa = 8.90/12.54 = 0.710. Notice that as the absolute slope of the iso-cost line increases, the likelihood of air shipment has increased because the absolute slope of the new iso-cost line is more nearly equal to the slope of the 45 degree iso-revenue line.

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1. The steepness of the line increases as the absolute slope increases.

Table 8. Costs of Producing A, R, and T With Reduced Costs of Air Shipping Costs and With a F.O.B. Price of \$2.50 per Carton

Cost	Per Unit of A		Per Unit of R	Per Unit of T
Procurement (f.o.b. \$2.50)		5.61	6.11	5.83
Shipping & Handling	6.86x1.01	6.93	2.77	3.52
Time Costs		.00	.02	.01
Total Costs Excluding the Cost for the Shipper's Time and Use of His Facilities		Ca = 12.54	Cr = 8.90	Ct = 9.36

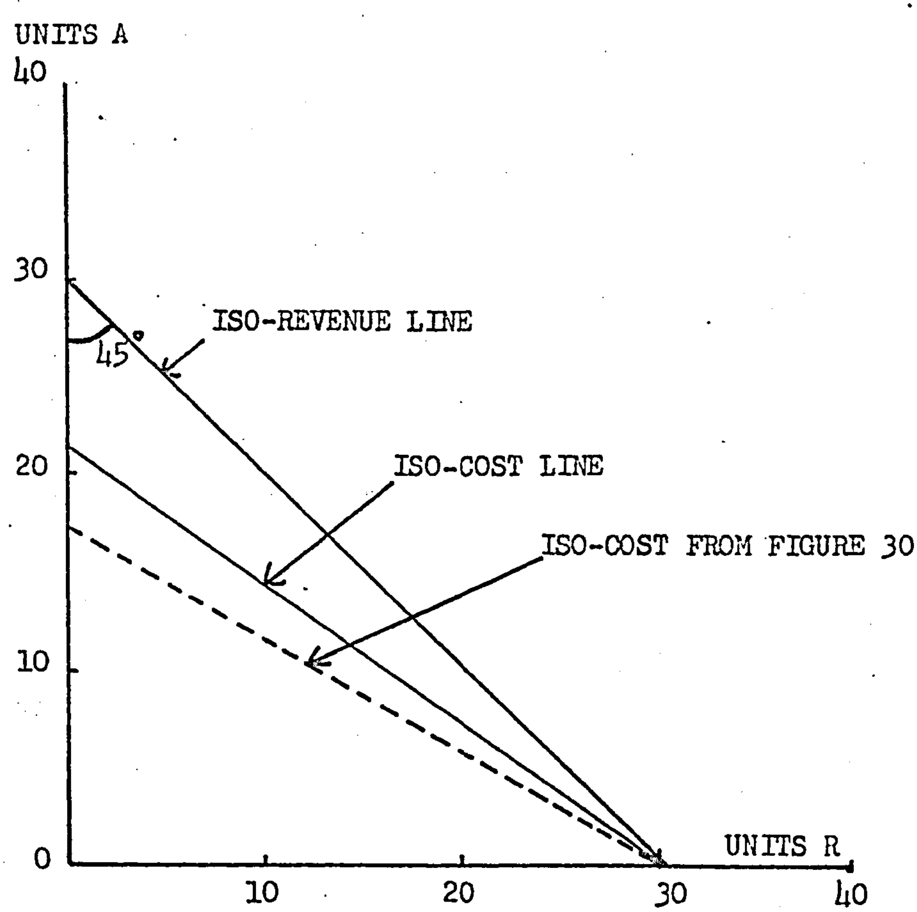

Figure 31. Product A-Product R Model for the Shipper in Salinas When Air Shipping and Handling Charges are Lowered 30 Per Cent

The Effect of Rising F.O.B. Prices

Table 9 represents the costs of producing A, R, and T with 30 per cent lower air shipping and handling costs and with a f.o.b. price of $4 per carton for lettuce in California. In Figure 32 the iso-cost line representing these conditions has an absolute slope of R3 = Cr/Ca = 12.57/15.90 = .791. The dotted line shown has an absolute slope equal to R2. This dotted line is the iso-cost line from Figure 31. The dotted iso-cost line has a cost constraint of $267, while the new cost constraint is $377.10.[1] As long as the prices paid for Pa remain equal to Pr the higher f.o.b. price will increase the likelihood of air shipment.

Break-Even Prices for Air Shipped Lettuce

Instead of drawing a diagram of the product-product decision process for each comparison needed, it is simpler to make the comparison mathematically. Table 10 shows the cost ratios for rail to air costs and for truck to air costs. These cost ratios provide the basis for determining how much the price of air shipped lettuce would have to exceed the price of rail or truck shipped lettuce under the conditions specified in Tables 7, 8, and 9. With the shipping costs that were in effect in September, 1969, and

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1. In Figure 4 this kind of situation was illustrated with the cost constraint for both iso-cost lines being equal.

Table 9. Costs of Producing A, R, and T With Reduced Air Shipping Costs and F.O.B. Prices of $4 per Carton

Cost	Per Unit of A		Per Unit of R		Per Unit of T	
Procurement (f.o.b. $4.00)	8.88x1.01	8.97	8.88x1.10	9.77	8.88x1.05	9.32
Shipping & Handling		6.93		2.77		3.52
Time Costs		.00		.03		.01
Total Costs Excluding the Cost for the Shipper's Time and Use of His Facilities		Ca = 15.90		Cr = 12.57		Ct = 12.85

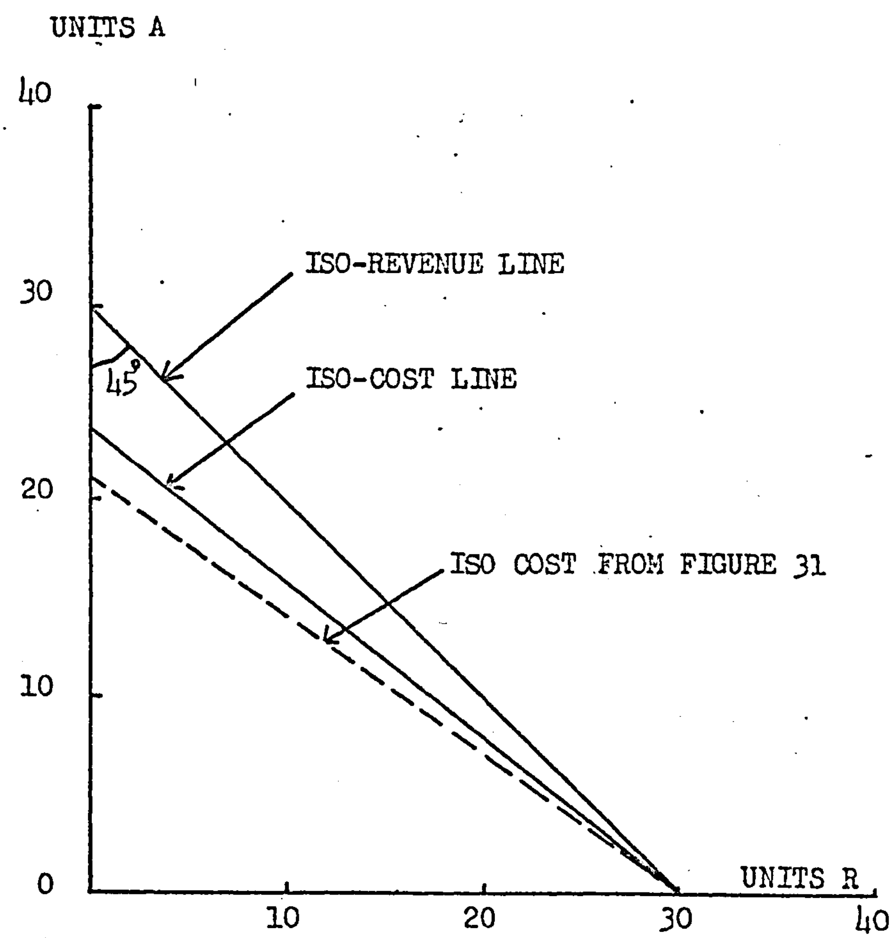

Figure 32. Product A-Product R Model for the Shipper With a F.O.B. Price of $4 per Carton

Table 10. Cost and Price Ratios for Shipping Lettuce by Air, Rail, and Truck from Salinas, California to Huntspoint, New York

Description of Computation	Based on Table 7 Data	Based on Table 8 Data	Based on Table 9 Data
Ca/Cr	$\frac{15.51}{8.90} = 1.743$	$\frac{12.54}{8.90} = 1.409$	$\frac{15.90}{12.57} = 1.265$
Therefore, Pa must exceed Pr by:	74 per cent	41 per cent	26 per cent
Ca/Ct	$\frac{15.51}{9.36} = 1.657$	$\frac{12.54}{9.36} = 1.340$	$\frac{15.90}{12.85} = 1.237$
Therefore, Pa must exceed Pt by:	66 per cent	34 per cent	24 per cent

f.o.b. price of lettuce at $2.50 per carton, the wholesale and retail prices of air shipped lettuce would have had to be at least 74 per cent higher than the prices for rail shipped lettuce. With the same conditions, except a 30 per cent reduction in air shipping cost and an f.o.b. price of $4.00 per carton, the air shipped prices would have to be only 24 per cent higher than the truck shipped prices before the two alternatives would be equally profitable. Table 10 illustrates that air transport becomes more competitive as air freight rates decline and as the f.o.b. price increases as suggested in the theoretical models of Chapter II.

Table 11 shows the computed wholesale level break-even prices for lettuce shipped by the various modes. If the shipper were to compare the air mode with the truck mode he would find that the differentials in prices needed to make air shipment feasible were lower than when he compared the air mode with the rail mode. The differentials in prices are computed per hundred pounds, by the carton, and by the head. For instance, the differential price per head under the conditions outlined in Table 7 for the rail-air mode comparison is 12.4 cents. As air shipping and handling costs decrease as outlined in Table 8, this differential shrinks to 6.8 cents per head. Also, the effect of increasing the f.o.b. price is a smaller

Table 11. Break-Even Wholesale Prices Per Hundred Pounds, Per Carton, and Per Head

Description	Based on Table 7			Based on Table 8			Based on Table 9		
	$/100 Pounds	$/ Carton	¢/ Head	$/100 Pounds	$/ Carton	¢/ Head	$/100 Pounds	$/ Carton	¢/ Head
Break-Even Price									
Air Lettuce A	15.51	6.98	29.1	12.54	5.64	23.5	15.90	7.16	29.8
Rail Lettuce R	8.90	4.00	16.7	8.90	4.00	16.7	12.57	5.66	23.6
Difference	6.61	2.98	12.4	3.64	1.64	6.8	3.33	1.50	6.2
Air Lettuce A	15.51	6.98	29.1	12.54	5.64	23.5	15.90	7.16	29.8
Truck Lettuce T	9.36	4.21	17.6	9.36	4.21	17.6	12.85	5.78	24.1
Difference	6.15	2.77	11.5	3.18	1.43	5.9	3.05	1.38	5.7

Source: Based on the cost ratios computed in Table 10 and the conditions outlined in Tables 7, 8, and 9.

differential as shown in the columns based on Table 9 conditions.

Table 11 clearly indicates that air shipping of lettuce would not be profitable unless there were substantial premiums for air shipped lettuce. Even with 30 per cent reductions in air shipping and handling costs the air mode could not compete in the New York City market unless there were substantial price premiums. At present, these price premiums must not exist because air shipment of lettuce is done only on an experimental basis. The absence of truck shipments in the New York City market is an indication that price premiums are not available. Even though truck shipments are several days faster in reaching this market, they have not replaced the predominant rail mode. Based on figures from Table 7, the break-even price between truck and rail shipment requires only about a one cent per head premium for truck-shipped lettuce.

The Prospects for Lower Air Freight Rates for Horticultural Products

The aircraft operating cost information presented in Chapter III indicated that in mid-1968, with a high proportion of the aircraft operated being DC-8 and B-707 class planes, the estimated cost per available ton mile was about 8.60 cents. Actually, these estimates are based upon the actual operating costs with a very low rate of aircraft utilization. For this reason, estimated cost per available ton mile must surely be a lower limit estimate of the cost per revenue ton mile that would occur if the airlines were able to operate their equipment at a rate of utilization that yielded the lowest possible cost per revenue ton mile. In this context, Brewer's (1966b) figures for 5.60 to 6.30 cents per cargo ton mile for DC-8 and B-707 aircraft seem unreasonably low.

The air freight rate for lettuce shipped from California to New York as reported in Chapter IV was $8.30 per cwt, or approximately 5.5 cents per ton mile. In mid-1968 the airlines received an average of about 25 cents per revenue ton mile for all cargo carried. This includes shipments over wide ranges of size and distance.

The lowest possible total cost per ton mile for the airlines over the routes currently operated is probably about twice the rate currently being charged for the lettuce shipments. It could be argued that the cost for the long California to New York shipment would be lower per ton mile than the average for all shipments, including some that are much shorter. However, it seems likely that the only way that this large discrepancy between costs and charges can be explained is by a "backhaul" type of phenomenon. It is widely known that the airlines carry more cargo on the flights to the west than on the flights to the east. It seems likely that if a large volume of western produce were shipped to eastern markets by air, this imbalance of shipments might disappear and with it the incentive for the airlines to quote such relatively low rates for lettuce.

The circumstances outlined in this section suggest that the airlines may not be willing to reduce their charges for shipping lettuce by the same proportion as their costs are lowered by the introduction of larger aircraft. It will probably be the middle to late 1970's before substantial quantities of the larger planes are used in all cargo service and the effects of the larger planes on produce rates will be known.

The Transition to Air Shipment in the Future

The transition to the use of air shipment for lettuce and for other fruits and vegetables will require the development of a consumer market for air shipped products. In order to demand a premium price in the retail outlet, the product must be recognized by the consumer as a better product. Because consumers are unfamiliar with the benefits of air shipped lettuce and its availability, there probably exists a substantial unexploited market. If the trend of rising per capita disposable incomes continues, there should be an increasing demand for premium quality produce.

Air carriers, retailers, and produce shippers will gain experience in marketing by air as they experiment with various types of air shipment. An interesting possibility for the future is the idea of chartered flights for fresh produce. A shipper may eventually arrange with retailers to ship a plane load of produce and charter the air carrier's plane directly. Problems with passenger and cargo schedules would be eliminated for the airline, and the shipper would be able to gear his operation so that the load was ready for pick up and delivery on more exact schedules. If a shipper were able to develop a worthwhile premium for air shipped produce he might possibly move part of his packaging and cooling and even a pre-processing area to the air strip. If it were possible to pre-cool the lettuce at the air strip, the shipper might be able to reduce his pick up and delivery costs.

The concentration of the production areas and the location of airports are important factors which would affect air shipping costs. In the Phoenix area there would seem to be good access to the airport for at least a sizeable portion of the lettuce growing and shipping industry. In the Yuma area the accessibility by B-747 and L-500 aircraft is less certain. Unless these new aircraft can be utilized, the airlines would probably not lower the present rates by 30 per cent as was done in figuring differentials in Table 11.

Perhaps the first profitable air shipments of lettuce or other produce will occur during the times when distant markets have high prices due to shortages in lettuce shipments. During the first week of harvest the air shipment may be competitive due to its rapid delivery.

Another possibility for air shipment would be the export market. Products that are field-ripened would be available to many distant world markets. Presently only about one per cent of the exported United States fruits and vegetables are shipped by air. Air shipments abroad have some advantages over air shipments within this country. The savings in damages are greater over the longer distances. The economies of the new aircraft are greatest over long distance flight. Overseas shipments must go by ship at speeds substantially slower than rail or trucks and additional time is consumed in loading and unloading. The resulting long shipping times by sea bring potential quality changes into greater importance.

In the future, Arizona will be mostly concerned with lettuce, citrus, and cantaloupes--the principal horticultural products for Arizona. A possible new crop for Arizona might be vine-ripened tomatoes. There is a firm in Tucson, Arizona, growing greenhouse, vine-ripened tomatoes that has made several small air shipments to large eastern cities. The results of these experiments are inconclusive at the present, but indications show that worthwhile premiums are available for vine-ripened tomatoes.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The lettuce, cantaloupe, and citrus crops of Arizona seem to be the most likely candidates for air shipment due to their importance to the Arizona economy as well as for the prospect of offering the consumers more desirable produce. Lettuce production and shipping is highly concentrated in terms of size and location. Lettuce is highly perishable, has a high value density, and would seem to be the most likely crop for the first air shipments.

The effect on the shipping patterns for fruits and vegetables of the jumbo jets like the B-747 and the L-500 will depend on several conditions within the transportation industry. Whether or not the airlines will be able to lower air shipping rates will depend on their ability to fully utilize the advantages inherent in the jumbo jets. Capacity and utilization are important factors that affect the airlines' costs, and these costs have a direct influence upon rates. If conditions are favorable the airlines should be able to lower present air shipping rates by 30 per cent after the jumbo jets are put into service.

Other new technology within the transportation industry could have substantial effects upon the shipping patterns for Arizona fruits and vegetables. Containerization and atmospheric control systems can help the rail and truck industry reduce losses in transit and can help increase the shelf life of the products they haul. Preprocessing of fruits and vegetables is another untried concept which could alter the shipping patterns. Fresh salads could be pre-packaged near the field and then shipped by air directly to the consumers' area. This reduces the amount of waste material hauled which helps lower transporting costs. The interstate road system will help the trucking industry because delivery times will be reduced.

The costs of shipping lettuce to New York City indicate that air shipment is very costly compared to truck or rail shipment. A differential in prices would have to exist before air shipments would be profitable. At present, this premium would be at least two-thirds the price of lettuce in New York City that was not air shipped--a price difference that consumers might not feel was justified by quality differences. A reduction of air shipping and handling costs of thirty per cent would reduce this premium about 50 per cent in most cases. This greatly increases the likelihood that consumers would pay the needed premium for air shipped lettuce. Consumers in New York City would still have to pay a substantial premium.

The first air shipments of lettuce will most likely be sent to distant markets. The export market may have the best potential of any markets Arizona shippers supply. Air shipments would be more likely when the overall prices of lettuce were high because then the premiums needed for air shipped lettuce would be lower. Also, air shipments are more likely when an undersupply exists in a given market. In this case a large differential in price for air shipped lettuce would exist because of the temporary unavailability of rail or truck loads. Once lettuce was being air shipped, it would most likely be from concentrated production areas that were near good airports. The Phoenix area would fit this description very well. Shipments of lettuce from Salinas are trucked to the San Francisco airport, a distance of about 90 miles. The lettuce produced in the Phoenix area is much closer to the airport.

It would be expected that if cantaloupes or citrus fruits were shipped by air the costs would be similar to those of shipping lettuce. The value density of these items is lower than lettuce, which makes them less likely candidates at present due to the high costs of shipping by air. Also, the perishability factor for these items is lower than for lettuce, which reduces the possibility of receiving a premium price. These crops will probably not move by air until the costs of air shipping are lowered past the point needed to permit air shipment of lettuce.

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