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# Predicting the Impact of New Technology Aircraft on International Air Transportation Demand



Raymond A. Ausrotas

Flight Transportation Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

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| | |
|---|---|
| $\alpha$ | coefficient of elasticity for the buying index |
| $\beta$ | coefficient of elasticity for the quality index |
| $B_i$ | buying index for year i<br>(US GNP for year i/1953 GNP ÷ Yield for US international airlines/1953 Yield) |
| $P_i$ | international passenger index for year i<br>(number of international air passengers to and from US in year i/1953 passengers) |
| $Q_i$ | quality index for year i<br>(1 + [airborne speed of US international airlines for year i - 1953 speed/1953 speed]<br>+ [available seats per aircraft of US international airlines for year i - 1953 seats/1953 seats]<br>+ [US international airline aircraft revenue miles for year i - 1953 miles/1953 miles] |

# SECTION I

## INTRODUCTION

A desire to see new places, meet different people, and perhaps conduct some business on the side has been an enduring feature of civilization. However, international travel remained largely the province of the adventuresome or the very rich until the advent of modern aircraft. The second half of this century has seen a steady expansion of the jet set as international air travel to and from the United States has risen from 1.1 million passengers (1950) to 32.8 million (1978).* While in 1950 half the overseas visitors went by ship, by 1978 the ocean liner customers had decreased to less than five percent of the total travelling public.

International travel is still small compared to the domestic air travel market. In 1938, when domestic trunks carried 1.2 million passengers, the airlines had two percent of the 27 billion intercity common carrier passenger miles. In 1950 airlines had increased their share to 14% (of 56 billion) and by 1978 the air share had risen to 84% (of 218 billion). In 1978, 120 million round trips by air were taken in the U.S., compared to 7.8 million U.S. citizen departures for an overseas destination.

Both domestic and international traffic statistics clearly surpass growth in population from 1950 to 1980 (152 million to 223 million) and Gross National Product ($534 billion to $1,481 billion, 1972 dollars). What was responsible for this surge of travel?

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*"International air travel" includes U.S. citizens and aliens taking air trips to and from Mexico, but not Canada; presumably for historic statistical reasons. "Overseas" travel excludes Mexico and Canada. Puerto Rico is generally excluded from both sets of statistics.

First of all, a reasonably safe and convenient vehicle was needed.

> "Most of the people who traveled on planes in the early 1930s 'had damn good reason to travel,' said C. R. Smith [President of American Airlines]. 'Their son fell off a horse, or they had to go to Mayo's --that kind of thing. There wasn't much discretionary about that kind of travel.'
>
> "The well-to-do flew. Since flying cost more, air travel was elite travel all through the 1930s. And of these, only the brave flew. A few might take a trip 'to see what it was like.' Others flew for the exaltation earthlings were still discovering in the sky.
>
> "But the dominating motive for the 474,000 passenger-flights taken in 1932 was speed. It could not have been anything else, Fortune said, because planes were not as safe as trains, and far less comfortable. One in every 2,200 who travelled that year was involved in a flying accident. Still, in 1932 a $5,000 insurance policy for a plane trip cost $2; for a train journey, twenty-five cents. Wives were still a powerful influence--they swayed men to stay off airplanes after every crash.
>
> "Manufacturers' representatives were the backbone of air travel in the 1930s. These were men who had to travel to sell, and the airlines sought their patronage." (Solberg, 1979: 220-221)

In the U.S., the DC-3 revolutionized airline travel. On the Atlantic, it was the DC6-B and DC-7 and the introduction of tourist class. When growth in 1951 had fallen to only 8%, it appeared that the limit of people who were willing to pay $711 for a round-trip ticket had been reached, and Pan Am introduced tourist flights--followed shortly by planes that were operated in part as first class and in (large) part as tourist.

> "...tourist class brought a fantastic upsurge in Atlantic air traffic --up 17% by 1953, 9% more by 1954, then up 19% in 1955, and 20% more in 1956. By 1958 low-fare air travel constituted two-thirds of the North Atlantic business, and Pan Am found that between 67 and 77% of those flying tourist had never been in the air before." (Solberg, 1979: 347-348)

In fact, Juan Trippe, Pan Am's president, said later "that the introduction of air coach ranks after Lindbergh's flight and the onset of the jetliner as the third major milestone of airline history." "The importance of that change, which preceded the arrival of jets, was that for the first time the ordinary man began to fly with us," Trippe said. (Solberg, 1979: 345)

> "The increase in population, in the moneyed class, in overall income played its part in this swift growth.... Tremendous promotion by the airlines and travel agents of economy fares and package vacations also had their effect." (Solberg, 1979: 406)

The arrival of the jets, starting with the Boeing 707 in October 1958 from New York to Paris and ending with the widebodies, did indeed result in a tremendous increase in travel. At last airplanes were able to fly over the weather and, combined with dependable fan jet engine power, the reputation of air travel for reliability, comfort, and safety became firmly established. Able to purchase economy class tickets, the public rushed in to fill the seats. By 1972, according to Gallup, half the people in the United States had flown at least once.

But even in the early days of jet travel, it was the business traveller who was the dominant passenger. The PANYNJ* estimated in 1969 that 5% of the passengers took 40% of all air trips. Across the Atlantic, as late as 1965, the full-fare paying passenger still exceeded the discount and promotional passenger. By 1972 this percentage had decreased to 16%, as the total of all air passengers went from 3 million to 13 million. (The International Air Transport Association [IATA] surveys indicate that 70% of business passengers pay full fare, compared to 20% of vacationers.) Thus, the big upswing in international travel has been in the pleasure travel class, while business travel has increased only slightly in the last decade.

The industry is still relatively young and dynamic. Across the North Atlantic, the primary international travel market, going through the air surpassed travelling

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*Port Authority of New York and New Jersey.

on water only in 1957. Even in this relatively well established market, trends are subject to rapid change. Growth had been positive from year to year (averaging 18% from 1957 to 1973, with annual increases ranging from 9% to 27%) until 1973, when the total traffic topped out at 14 million passengers. It was 1977 before 1973 levels were reached again.

Did the factors that caused growth reverse themselves, or did new factors appear and overwhelm past causes? Do the aggregate numbers hide differing cause and effect relationships? This report is an attempt to explore questions of this nature.*

* The author would like to acknowledge the guidance and editorial advice of Dal V. Maddalon of NASA Langley Research Center. In addition, data provided by and discussions with John Feren of Douglas; George Sarames and Ron Selter of Lockheed; and Dennis Mathaisel, Bob Simpson and Nawal Taneja of MIT have been invaluable.

## SECTION 2

## TRAVEL GROWTH: CAUSES AND EFFECTS

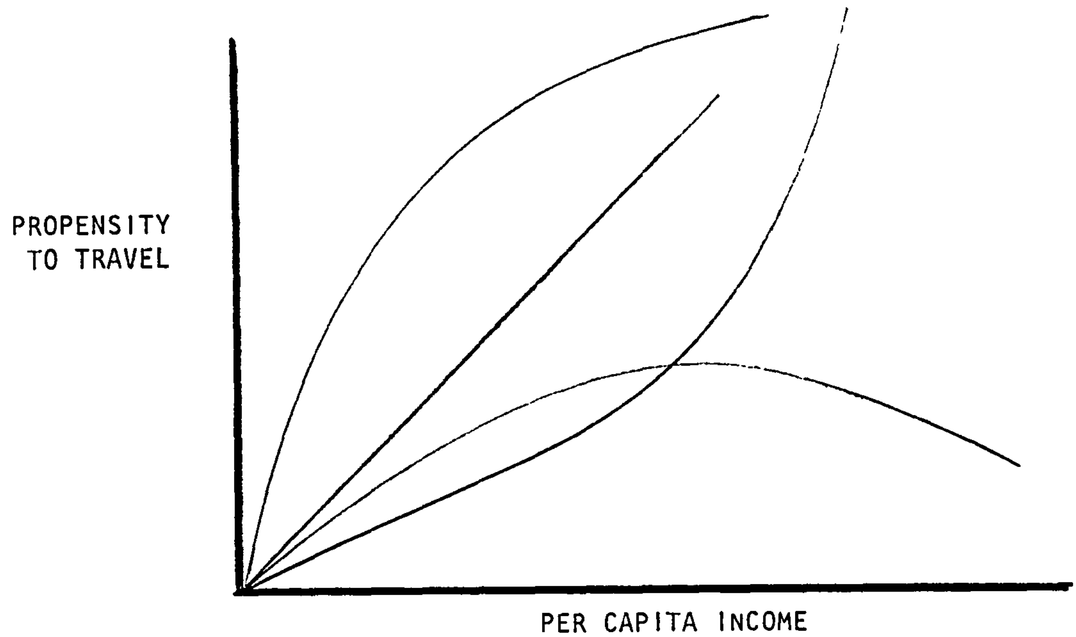
Given a choice, passengers will weigh convenience, comfort, safety, speed, appeal of destination, and cost in deciding how and where to travel. Not all people consider these factors to be of the same importance in making their decision, nor do they perceive these attributes in the same manner. Thus across the Atlantic in 1980, one can cruise on the Queen Elizabeth, take the Concorde, or fly standby on Laker Airlines, to name but three choices which are all in high demand, at least in season.

A distinction has traditionally been made between business and personal travel. Business travel is most often concerned with sales and visiting company facilities. Attending conferences, meeting clients or vendors, and performing emergency service calls are also frequent reasons for business trips. Ever since the picturephone was a gleam in some futurist's eye, alarmists cry out that business travel is doomed with each advance in telecommunications technology. Yet the fact remains that employees generally consider a certain amount of travel as a perquisite and will find reasons to continue to climb on airplanes even when perfectly good three-dimensional, audio-visual links (in color) will be available. (This theory clearly does not apply to persons who, as part of their job, travel constantly; often-repeated trips across the Atlantic pall even faster than short-haul day trips.)

Personal travel, in turn, can be thought of as divided between pleasure and emergency. Emergencies are the parents observed by C. R. Smith rushing to see their offspring who have fallen off horses, or trips which have a similar degree of urgency or specific time constraint. This type of travel is generally independent of fare levels or economic conditions and is fairly probabilistic, increasing with population growth. Pleasure travel, alternatively, is almost totally discretionary; i.e., the trip can be put off or not made at all. However, the trip is made because of a specific desire (visit long-lost relatives overseas, play the roulette wheel, bicycle across Ireland) or because of conditioning by the travel and tourism industry (ski Portillo in the summer, fly to California for only \$88, see the USA during the Bicentennial celebration).

Clearly different reasons underlie business and personal travel, and also subsets within these two major classifications. Motives for travel also vary with a country's state of economic development and travel infrastructure (unavailability of public places to stay severely reduces the incentive to visit), as well as the specific travel mode (ground--private car, bus, train, etc.; air; water). Thus people take trains for different reasons than they take airplanes: they may be train buffs; they may be afraid to fly; they may prefer to see some of the scenery along the way. In general, however, when people travel, they pick the destination and the mode simultaneously; they do not first choose a place to visit and then contemplate a means of reaching it. For international travel, realistically speaking, there is no longer a modal choice.

Given countries of similar economic development, causes for personal travel will vary with a person's economic status, social status, age, educational level, and travel experience. Human behavior, individually and in groups, is subject both to various degrees of constraint and self-determination, and generalizations about its causes and effects are always tentative and of uncertain validity over time. Thus, although many general theories of travel have been proposed, none has been totally satisfactory. Even such seemingly simple hypotheses as, for example, the probable changes in propensity to travel with increasing income (sketched below) have no valid proof. In fact, often the "woodwork" theory works as well as any other: you put in a flight from A to B and people come out of the woodwork. Thus, demand is directly related to supply, without need for other explanatory variables.




In economically advanced countries, a number of other factors have been held responsible for increased international pleasure travel. The combination of increasing leisure time and growing middle class has created world tourists unlike anything Thomas Cook envisioned when he founded his organized tours in the 1840s. Around then, the average work week was about 70 hours; by now, that has been cut in half. This, together with longer vacation periods, has made time available to people who choose to travel. The long-term rise in real disposable per capita income created a larger, more educated middle class which has more to spend on discretionary items such as travel. In the meantime, technological advances in air transportation have allowed, for example, the lowest one-way fare (in 1979 dollars) from New York to Los Angeles to repeatedly fall from $725 (1929) to $470 (1949) to $210 (1969) to $125-$88 (1980), while at the same time the duration of the trip has dropped from 25 hours (1929) to 12 (1949) to 5 in the jet age.

Psychological reasons have also been advanced for international tourism. People are said to travel for the sake of change; to get away from work that may be highly repetitious or routine and without autonomy; or even to get away from home and the necessary work that comes with its maintenance. People want to go to places that are more interesting, more exotic, more romantic, and in general more pleasurable than their homes.

Whether such places actually exist is of course debatable, but the travel and tourism industry (tourist sites, airlines, hotels, aircraft manufacturers, travel agents, etc.) has learned to market its products well and gradually has been educating the public that travel is good for you. On the West Coast, American advertises the charms of Boston and New York; on the East Coast, Los Angeles and San Francisco are featured. Other communication advances of the last century such as radio, television, and motion pictures have certainly not diminished people's curiosity about faraway places with strange sounding names. Live TV coverage is possible from anywhere in the world via satellites; it is no longer necessary to wait for the travelogue at the local cinema. Thus, people are conditioned to view the world as readily accessible and to consider travel not as a mere vacation, but as an integral part of life, and the more frequent and farther away, the better.

Thus economic, technological and even subliminal causes are at work to insure that international pleasure travel takes place. As global trade continues to expand, with multinational corporations leading the way, the manufacturers' representatives who were flying in the DC-3's in the 1930s are now travelling on international airlines. When business and political conditions change from country to country, there is more or less travel, depending on the nature of any company's business. One hypothesis is that as a country's gross national product decreases, travel from that country also diminishes (travel budgets are the first to feel the downturn in a company's fortunes, since they are the easiest to cut). This theory can be countered by another: that as a country's economy encounters a slump, its salespersons should be increasing their calls to other countries to get rid of inventories which are not moving at home.

Motives for business travel thus can be as capricious as those for pleasure travel. The manufacturers' reps flew rather than drove because they covered more territory per day and increased their sales more than enough, presumably, to offset the higher transportation costs. Today's (highly paid) executive flies the Concorde across the Atlantic to save three hours of travel and to eliminate jet lag, thus improving his productivity and well being, not to mention self-esteem. Since a hundred-thousand-dollar-a-year man's time is worth only \$50 per hour, while the Concorde carries a premium of \$300 per hour versus cheaper alternatives on the London-New York run, clearly more than a simple dollar-travel time savings tradeoff is made by the Concorde passenger.

The value-of-time concept has often been used in transportation studies to compute the potential benefit (to society) for improving transportation networks (roads, railroads), or to estimate the potential demand for faster airplanes (Gronau, 1970). However, it is a theory riddled with caveats. For example, whose value should be considered? The individual's? The company's? Society's at large? The value also changes with the amount of time saved, the frequency of travel, and the use to which the time gained is put, as well as level of personal income. The Concorde wins its share of travelers, about 70-80 percent of whom are on business, largely because it saves not just three hours of travel time but because it minimizes the effects of jet lag; in effect, due to time zone changes, the Concorde gains a day or more.

Conceptually, business travel should be more closely related to the availability (supply of seats) and, to a lesser degree, the quality of service (frequency and speed) in a market than to the price of the ticket: the fare is only one component of the total trip cost to the company. As in the Concorde example, increased employee productivity can absorb sizeable air fares. The ability to get an employee there and back in a reasonable time is now a possibility from United States gateways to all over the world. Although there may be only once- or twice-a-week service to some more remote outposts, improving this service will not lead to more business travel. A decent supply of air service is a necessary condition for business travel, but it is not sufficient. Unlike domestic short-haul markets, where increasing frequency often leads to more air travel (because it becomes more attractive compared to driving), in long-haul international travel markets, where there is no viable alternative, travellers adjust their trips to meet the airlines' schedules. As noted, although flights and seats across the North Atlantic proliferated during the 1970s, business travel expanded only slightly.

The spread of small and large multinational corporations and banks, through acquisition of foreign companies or establishment of overseas branches, has fueled overseas travel since World War II. The 1980 exports of goods and services were 341 billion or 13% of the US GNP, whereas in major Western European countries this percentage ranges from 25% to over 50%. This is natural enough: the United States has a large internal market, whereas European nations are forced to trade to survive. But the interesting trend is that in 1970 the export percentage was only 6% (of $992 billion); imports during the same period have risen at approximately the same rate from $59 billion to $314 billion. Thus even the United States is becoming more trade-oriented. Recently exports have been helped by the relatively cheap US dollar, while the dollar volume of imports is being made up to a larger degree of petroleum and related products following OPEC price increases. (The imports of crude oil and products rose from 1.2 billion barrels (1970) to 3.0 billion (1978) while the dollar value increased from $2.8 billion to $39 billion.) However, the United States currently shows a surplus in those high value-added technological industries which naturally lend themselves to exporting, such as aerospace products, where the US exports in 1980 were $14.6 billion compared to imports of $2.8 billion. As long as the US's comparative advantage persists, exports can be expected to continue to increase, and with it international business travel.

As airlines aggressively attempt to fill their empty seats with discount passengers, the business traveler is faced with higher load factors and deteriorating service in economy class. To combat this negative image, some international airlines are establishing a third "business class". Other airlines are deliberately advertising themselves as the businessman's airline and are attempting to capture the high yield travelers rather than fight for the mass market. If businessmen perceive travel as becoming more onerous, their solution may be the corporate aircraft or substantial reduction of travel. In the future, new technology aircraft may become a powerful marketing force in attracting the business traveler.

## SECTION 3

## FORECASTS: METRICS OR WIZARDS?

Unequivocally, it can be stated that without long range jet aircraft there would be no world tourism. Just as clearly, it can be said that many "other" things are at work. But how much of each thing is cause and how much effect? Is it possible to judge? Questions of logic arise: for something to be a cause, it must precede its effect; but what if more than one thing must be present, either sequentially or contemporaneously? Hicks (1979) discusses these problems of causality in economics and notes that, in economics, problems are not static. Events are constantly occurring which have not happened before and Hicks thus cautions the reader to be extremely wary before attempting to transplant scientific methodology to economics, even the type that Berlinski (1976) felicitously calls

> "The...metrical sciences - econometrics for economics; polimetrics for political science; biometrics for biology; even cliometrics for history - whose task is to interpose themselves between the broad-ranging and frequently untestable assumptions of a given theory and the mass of data the theory is meant to confront."

Is it possible to use the metrical sciences to develop a theory for demand of international air transportation?

First, just as in economics, there is the problem of aggregation: to accurately describe the demand for travel requires a model which takes into account the decisions of each individual traveller. Since this is (currently) impossible, travellers are aggregated and biases are introduced. Whether this is enough to separate the resulting model from reality depends on the size of the aggregation errors and the overall stability of the model. Berlinski notes that the social and biological sciences are marked by discontinuity and divergence: where gradual changes entail dramatic effects or where small changes in the initial conditions cause subsequent states to expand indefinitely. The intrinsic discontinuity and instability of society, politics, and economics then become an objection in principle to well-ordered mathematical models purporting to reflect reality.

Still, it appears necessary to somehow assay forecasts. After all, Armstrong (1978) has unearthed evidence that the fall of Rome could be attributed to the law promulgated by Emperor Constantius (A.D. 357) forbidding

> "anyone to consult a soothsayer, a mathematician or a forecaster...may curiosity to foretell the future be silenced forever."

In the air transportation industry, builders of aircraft have a definite need for estimating how many airplanes will be bought since, without adequate forecasts, their planning will go astray indeed, as Wallace (1974) pointed out even as "Last one to leave Seattle please turn out the lights" billboards and bumper stickers appeared.

Airport managers all over the world need good forecasts for facility planning. This is true at both ends of the scale. Overoptimistic forecasts have resulted in white (or gray) elephants such as Dulles (U.S.), Köln/Bonn (West Germany), and Mirabelle (Canada). In addition, massive master plans were undertaken that for a variety of reasons (not necessarily rational) were never executed (London's third airport, New York's fourth, and Toronto's second). Underestimates have caused clogged access roads, jammed terminals, and lack of gate space; here the list is endless.

Airlines of course use forecasts as a matter of survival. Managerial actions based on bad forecasts can doom an airline, or lead to a shotgun merger. And finally, although by no means least of all, the U.S. government, which is responsible for a large part of the aviation infrastructure, requires an understanding of likely future developments to make effective plans for aeronautical research and development, air traffic control facilities, FAA towers, etc. Given these obvious customers, many air travel forecasts indeed have been generated over the years, even excluding those that are company confidential and which outnumber the public ones by a large margin.

Forecasts can be grouped by various categories according to their theoretical underpinnings. Chambers, Mullick, and Smith (1971), in their widely cited Harvard Business Review article, considered three general types: qualitative techniques, time series analysis, and causal models. Armstrong and Grohman (1972) assumed the break to be between naive and causal methods: in naive methods, projections are made considering data only on the variable in question, while in causal methods, an attempt is made to link external factors to the variable being forecasted. (These causal variables are then projected to arrive at the forecast.) Naive forecasts resemble the work of pure chartists on Wall Street, where the future of stock or commodity prices is predicted by observing only motion of the price itself. Yet chart theory is obscure enough to allow two technicians, looking at the same pattern, to arrive at different opinions, not only about the magnitude but also about the direction of the next price move.

Armstrong (1978) later devised a much more elaborate classification scheme, starting with subjective versus objective methods (a forecast made using objective methods, when they are reasonably well defined, can be duplicated by a person other than the initial forecaster; this is usually not the case for subjective methods). The objective methods are then split into naive and causal branches, with econometrics hanging at one extremity of the causal branch. Many other schemes for categorizing forecasts have appeared. Generally, however, if it is necessary to describe forecasts, the subjective versus objective, or wizardry versus metricality, division is sufficient.

The theory underlying the forecasts must be carefully spelled out by both wizards and people using relatively conventional statistical techniques alike. Unless such an explanation is provided, forecasts can be no more than extrapolation. In far too many cases, the theory is discussed (sometimes perfunctorily, sometimes in great detail) and then it is noted that unfortunately this theory cannot be tested, usually due to data limitations. Unfortunately, elaborate mathematical variations are then undertaken to cover the data deficiencies, while at the same time limiting and simplifying assumptions are made which totally divorce the model being perfected not only from reality but also from the theory that was supposed to be the basis for the forecast. No amount of statistical razzle-dazzle can hide the fact that what is left are common observations festooned with the trappings of rigorous mathematics.

The trouble with data limitations is real enough, particularly in international travel (see, for example, Kanafani and Behbehani, 1979; Hogenauer, 1980). Airlines and countries hide traffic data for competitive reasons. Economic activity data, especially for less developed countries, are unavailable to the level of detail necessary for metrical analysis. And everybody likes to keep his own set of statistics, making comparisons between countries and regions, if not impossible, then tedious and time-consuming.

For example, Eriksen (1977) has developed exceedingly complex simultaneous equation demand models for individual longer haul U.S. domestic markets. The data that are required for these models to produce forecasts are so detailed that it is impossible to use these equations for international passengers without damaging the underlying theory through oversimplifying assumptions.

Even when data are available, an interplay of effects usually exists which makes it difficult to determine which particular causes are producing changes in travel patterns. Almost all theories about travel include increased speed (or less travel time) as a cause for traffic growth, with business travel generally being more sensitive to time savings. For example, in one of the early transoceanic forecasting models used for projecting SST travel, Boeing (1966) suggested using the following two formulas:

$$(1)\ \Delta \log \text{business passengers}_{ij} = \Delta \log P_i + 1.4\,\Delta \log PCG_i - 0.7\Delta \log \text{yield}_{ij} - 0.3\,\Delta \log T_{ij}$$

$$(2)\ \Delta \log \text{personal passengers}_{ij} = \Delta \log P_i + \Delta 1.7 \log PCG_i - 1.2\,\Delta \log \text{yield}_{ij} - 0.2\,\Delta \log T_{ij}$$

where:

$P_i$ = population of originating country

$PCG_i$ = per capita GNP of originating country

$\text{yield}_{ij}$ = weighted average yield on route from city i to city j

$T_{ij}$ = flight time from city i to city j

Disregarding for the moment the overall validity of the models, they do imply that business travel is more responsive than pleasure travel to higher aircraft speed, less sensitive to changes in the economy, and considerably less affected by increases in ticket prices.

Since any kind of econometric model ultimately needs an experimental demonstration of cause and effect relationships, the introduction of the 747-SP (Boeing Special Performance 747, slightly smaller but with the same power and thus able to make longer nonstop flights than the standard wide-body) and the Concorde would, on the surface, appear to provide an opportunity to test some of the travel hypotheses.

Prior to May 1976, the New York-Tokyo market was served by daily direct service from Japan Air Lines (DC-8 with a stop at Anchorage), Northwest Airlines (747 via Seattle) and Pan American (747 through San Francisco). In May 1976, Pan American introduced the 747-SP as nonstop service on the New York-Tokyo run, reducing travel time from 17 hours to about 14 hours. It would appear that a ready test of travelers' sensitivity to time savings could now be demonstrated, but after the initial transient, a host of other issues began to complicate matters. The foremost was carrier image, as Japan Air Lines countered with a DC-10 and stepped up advertising. Since the trip still took about 14 hours on the SP, the promise of better service for a long flight on JAL was a powerful marketing gambit. The Japanese, as do other foreign citizens, in general, also prefer to fly on their own airline if available and at all competitive. Traffic patterns are also distorted by the insistence (strong encouragement) of governments that their employees (and contractors) use their national airline.

Another external variable was the availability of myriad connections which were almost as fast as the one-stop direct service and which were particularly appealing to people who prefer (or can afford) to break their transpacific journey into smaller segments to make it less wearing. To these travelers, the availability of nonstop service was irrelevant. Further, travelers' sensitivity to time savings cannot be assumed to be constant: i.e., three hours saved off a trip of six hours is perceived differently from three hours saved out of seventeen. To truly demonstrate cause and effect relationships, a far more controlled experiment would have to be devised than the introduction of the 747 SP on a competitive multi-carrier market. (In other markets where the SP was introduced, for example, Los Angeles-Auckland, San Francisco-Hong Kong, it offered no substantial time savings over standard wide body jets.)

The Concorde case is even more complex than the SP, since the fare was simultaneously increased 20% over first class. When the Concorde was introduced in May 1976 on the Paris- and London-to-Washington, D.C. routes, it was the only supersonic service across the Atlantic and it attracted not just the Paris/London-Washington traveler, but also connecting passengers; one-third of all Concorde passengers transfer at one end of their flight and another third at both ends (Dubin, 1978). In fact, when the Concorde was finally allowed to land at Kennedy Airport in New York, more than one half of the traffic left the Washington run. The London-Washington route has always had higher load factors than Paris-Washington, further indicating that passengers who generally had better connections in London were the mainstay of the Washington route (see Tables A.1 and A.2 in Appendix).

The travelers on the Concorde are predominantly on business; surveys undertaken by British Airways and Air France have shown consistently that they constitute over 70% of the passengers. One long-standing theory had been that the Concorde would siphon off the first-class passenger from conventional jets; yet British Airways has recently claimed that first-class traffic has actually increased on their wide-body flights because of the marketing spinoff from the Concorde. If businessmen value their time, they also value their money; they do not necessarily fly first class when the economy section gets there just as fast, although SST studies assumed that largely first-class traffic would be attracted to supersonic service. For example, Leyman (1979) estimated that, if there were a 20% surcharge over first class, 10% of economy and 75% of first class traffic would be diverted to SST service, given 40% time savings. However, business travelers use first class about 20% of the time; yet 80% of the economy discount business travelers surveyed were willing to pay a 20% surcharge to save 6-1/2 hours of a 10-hour trip (Landes and Matter, 1979). Even with caveats about survey techniques (i.e., it is one thing to talk about paying and another thing to actually do it), this indicates that the supersonic market may be much broader than is generally indicated by the standard time-value-of-money studies or the first-class-diversion approaches.

However, it is difficult to develop, and more importantly, to verify, a realistic diversion model based on Concorde data, because of three basic problems: limited data, off-line traffic, and marketing considerations. The data limitations apply to knowledge of demographic and socioeconomic characteristics of the travelers and traffic data of non-U.S. carriers. Off-line problems are best illustrated by the sharp drop-off in traffic on the London and Paris to Washington routes in December 1977 noted previously, which was not related to any airline activity on these links but to the introduction of Concorde service to New York from London and Paris. (Attempts have been made to compensate for off-line traffic; Dubin (1978) for example.) Attempts to quantify the Concorde share on the Paris-Rio/Caracas and the London-Bahrein routes founder due to lack of traffic data and the diversity of alternative flights. For example, against a twice-weekly Concorde service (Paris-Rio), Air France also flew 747s nonstop and one-stop three times weekly; Varig had five weekly frequencies each of 707s and DC-10s; and Aerolineas Argentinas had two 707 flights. In the New York-London run in 1979, there were six daily 747s, Laker's DC-10s and assorted other aircraft.

In situations like these, where traffic flows not from city to city or even country to country, but continent to continent, the most reasonable way to assess Concorde potential is not an equation relating traffic share to frequencies, fares and travel times (see, for example, Swan, 1979), but to put the woodwork theory to work. To be sure, it is useful to first estimate the transoceanic business flows and guess at the total that might be diverted to a higher speed aircraft to make sure that the planes will not fly empty, but ultimately the load factors will be determined by the convenience of the service for the business travelers. Thus the Concorde is in high demand on the New York runs, but weak on other routes where alternative service is comparable. By providing more attractive transatlantic service, Concorde's percentage of United States-Europe traffic has risen from 0.45% (55,600 of 12,082,152 in 1977) to 1.1% (168,850 of 14,868,723 in 1979). (The woodwork theory also argues that British Airways should keep increasing the Concorde New York frequency.)

If the SP and the Concorde are not sufficiently controlled experiments to determine the advantage of higher speed travel due to unstable and incomplete data, what other recourses are available to test hypotheses about international travel?

Use of aggregated data appears reasonable, and many attempts have been made to forecast international regional market traffic. The North Atlantic, the densest route, has attracted the most attention.

On the wizard side, Bratbak (1971) looked at the North Atlantic and concluded that traffic was probably determined more by the travelers' perception of their future economic health (consumer confidence) and the availability of seats from year to year than anything else.

IATA updates its regional North Atlantic five-year forecasts every June, averaging the guesses of many forecasts. One cannot argue (too vehemently) with wizards, except after the fact; the flaws in the metrical attempts are more apparent.

Even when the proper causal variables are identified, i.e., the theory is plausible and is not mistaking correlation for causation, the equations assume (as causal models must) that the causal variables can be measured and projected accurately (more accurately than traffic itself) and that the relationships will remain constant. These assumptions, which are basic to econometricians and other metricians, are extremely questionable for international traffic forecasts.

Some metrical efforts (Taneja, 1971, to the more recent Cigliano, 1979) have attempted to statistically fit GNP, income, fare, and some measure of quality of service to North Atlantic passenger flows. Feren (1979) devised the following formula for German travel to the United States (for traffic, see Table A.3):

$$\text{Log (GER TFV)} = 1.711 + 1.236 \text{ Log (REAL WAGES)} - .394 \text{ (Log YIELD)} - .982 \text{ Log (RELINF)} + .063 \text{ Log (BI CEN)}$$

where:

GER TFV = total foreign visitors arriving in the United States from West Germany

REAL WAGES = compensation of employees in constant 1975 Deutsche marks

R YIELD = real average fares on the North Atlantic (Europe, U.S. & Canada) converted to constant 1975 prices using the CPI of West Germany

RELINF = a relative inflation variable measuring the change in prices in the United States against Germany after correction for exchange rate movements

$$\frac{\text{US CPI}}{\text{GERMANY CPI}} \times \frac{\text{Deutsche Mark}}{\text{U.S. Dollar}} \text{ exchange rate index}$$

BI CEN = a dummy variable to account for the traffic stimulation resulting from the 1976 U.S. Bicentennial

Although statistically appealing, this equation demonstrates one major caveat of metrics, accurate prediction of exogenous variables. Correctly guessing RELINF will assure the forecaster a prosperous future not only in the airline business, but also, more lucratively, in the currency markets.

The problem of measurement of variables is demonstrated in U.S.-Venezuela traffic (Table A.4). Venezuela is in fifth place of all alien-generated traffic to the United States and travel has gone up by a factor of three from 1974-1979, even though the Venezuelan bolivar is tied to the dollar, so there has been no relative currency advantage. Further, the Venezuelan GNP did not grow faster than that of the U.S.; charter flights accounted for only 1% of the total traffic; and business travel only accounts for about 5% of the total traffic, according to the not-always-reliable World Tourism Organization reports. What the aggregate numbers hide is the growing, ever more affluent, middle class in Venezuela, which can afford to travel and is taking advantage of the relatively cheaper goods and services which are available in the United States. Thus, although the gross economic indicators imply that no special causes for travel to the United States exist, over the course of the past five years the number of Venezuelans coming to the United States has tripled, spurred on in part by the development of Miami as a major Latin American hub; over half of the total U.S.-Venezuela traffic is over the Caracas-Miami link.

While prediction and reliability of causative variables present severe problems in metrical forecasting, they are not as serious as the basic problem of instability: even if a correct theory is postulated and the proper causes have been identified using rigorous analysis of historical facts, there is no guarantee that the past will be prologue. Perhaps here a touch of the wizard becomes necessary; Wallace (1979) shows a possible way out through indexing and looking at a range of possible events.

In attempting to devise an explanation for the growth of the US domestic passenger traffic, Wallace developed two quality and price indexes, arguing that quality is as important as price for demand determination. The factors influencing quality include technological improvements in aircraft (speed, size, and range, as shown in Table 1), and growth of the airline industry

TABLE 1

COMMERCIAL AIRCRAFT -- TRENDS IN CHARACTERISTICS AND PRODUCTIVITY

| Type of Plane | Date of First Service | Full Payload Range (Miles) | Seats | Speed (mph) | Annual* ASM's (000) |
|---|---|---|---|---|---|
| Ford Tri-Motor | 8/ 2/26 | 570 | 14 | 100 | 4,088 |
| Douglas DC-3 | 6/25/36 | 500 | 28 | 180 | 14,717 |
| Douglas DC-6 | 4/27/47 | 2,750 | 56 | 310 | 50,691 |
| Lockheed Constellation | 6/17/47 | 3,000 | 64 | 300 | 56,064 |
| Douglas DC-7 | 11/29/53 | 2,800 | 99 | 360 | 104,069 |
| Lockheed Super Constellation | 4/ 1/55 | 4,620 | 99 | 335 | 96,842 |
| Lockheed Electra | 1/12/59 | 2,770 | 98 | 450 | 128,772 |
| Boeing 707 | 10/28/58 | 3,000 | 181 | 600 | 317,112 |
| Douglas DC-8 | 9/18/59 | 4,300 | 176 | 600 | 308,352 |
| Boeing 727-200 | 12/14/67 | 1,750 | 189 | 600 | 331,128 |
| Douglas DC-8-61 | 2/24/67 | 5,300 | 259 | 600 | 453,768 |
| Douglas DC-10 | 8/ 5/71 | 2,760 | 380 | 600 | 665,766 |
| Boeing 747 | 1/22/70 | 5,800 | 490 | 640 | 915,712 |
| Concorde | 1/21/76 | 3,800 | 100 | 1,300 | 380,000 |

* Assuming a constant utilization of eight hours per day -- this actually overstates the capacity of older models and understates most of the jets. The formula for annual capacity is: seats x hours per day x speed x 365. The numbers derived do not reflect actual productivity in commercial service because mixed class seating reduces the actual seats and actual cruising speeds are about 10% under the maximum.

in general, reflecting service improvements (additional cities served, improved and more frequent schedules, more direct service). A similar composite quality index for international air transportation can be constructed by using C.A.B. data on U.S. international operations. Revenue aircraft miles in service are taken as a proxy for service improvements, and aircraft speed and average number of aircraft seats as used as proxies for technological improvement. The year of the introduction of the DC-7, 1953, is chosen as the base year for indexing.

To account for inflation while simultaneously considering ticket price and traveler income, the current dollar yield index (the income airlines actually receive per passenger-mile) is divided into the current dollar U.S. GNP index to establish the ability-to-buy index. (GNP is used rather than disposable income to account for both business and personal income expansion.) This index, as Wallace points out, measures the change in travelers' ability to purchase air travel, given the combinations of changes in prices and incomes as U.S. citizens actually experienced them; i.e., if wages inflated faster than airline yields, it became easier to purchase airline tickets.

Using these buying and and quality indices, it is possible to construct an international passenger traffic model by analyzing the historical relationship between these pseudo-causative variables and the passenger traffic index. The buying index and the quality index are shown in Figures 1 and 2. The supporting data are shown in Tables A.5 and A.6 in the Appendix.

Performing a regression analysis on the data in the form:

$$\Delta \log P_i = \alpha\Delta \log B_i + \beta\Delta \log Q_i$$

where:

$P_i$ = passenger index (international passengers for year i/1953 passengers)

$B_i$ = buying index ([$GNP_i$/1953 GNP] ÷ $Yield_i$/1953 Yield)

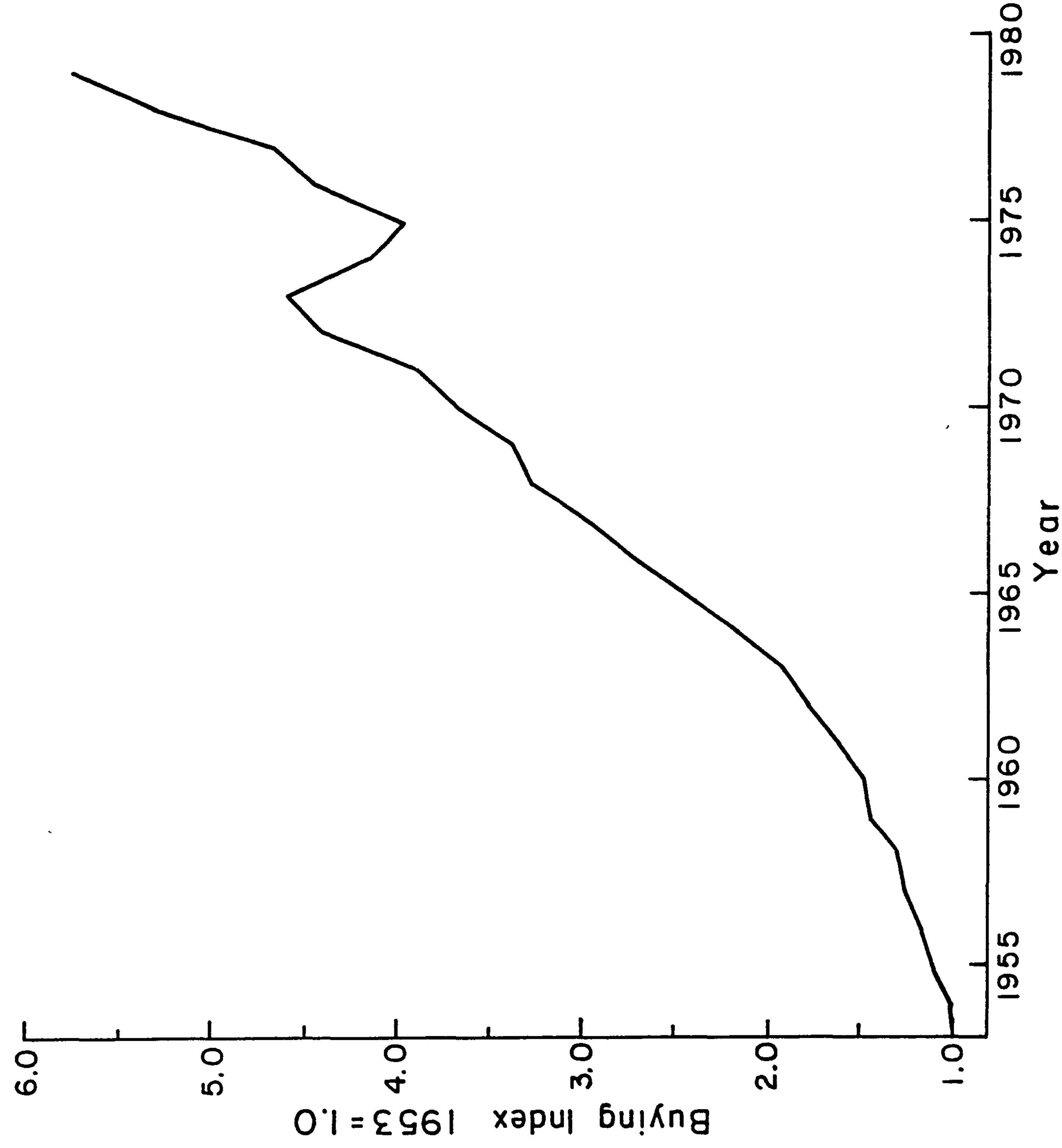



FIGURE 1 BUYING INDEX

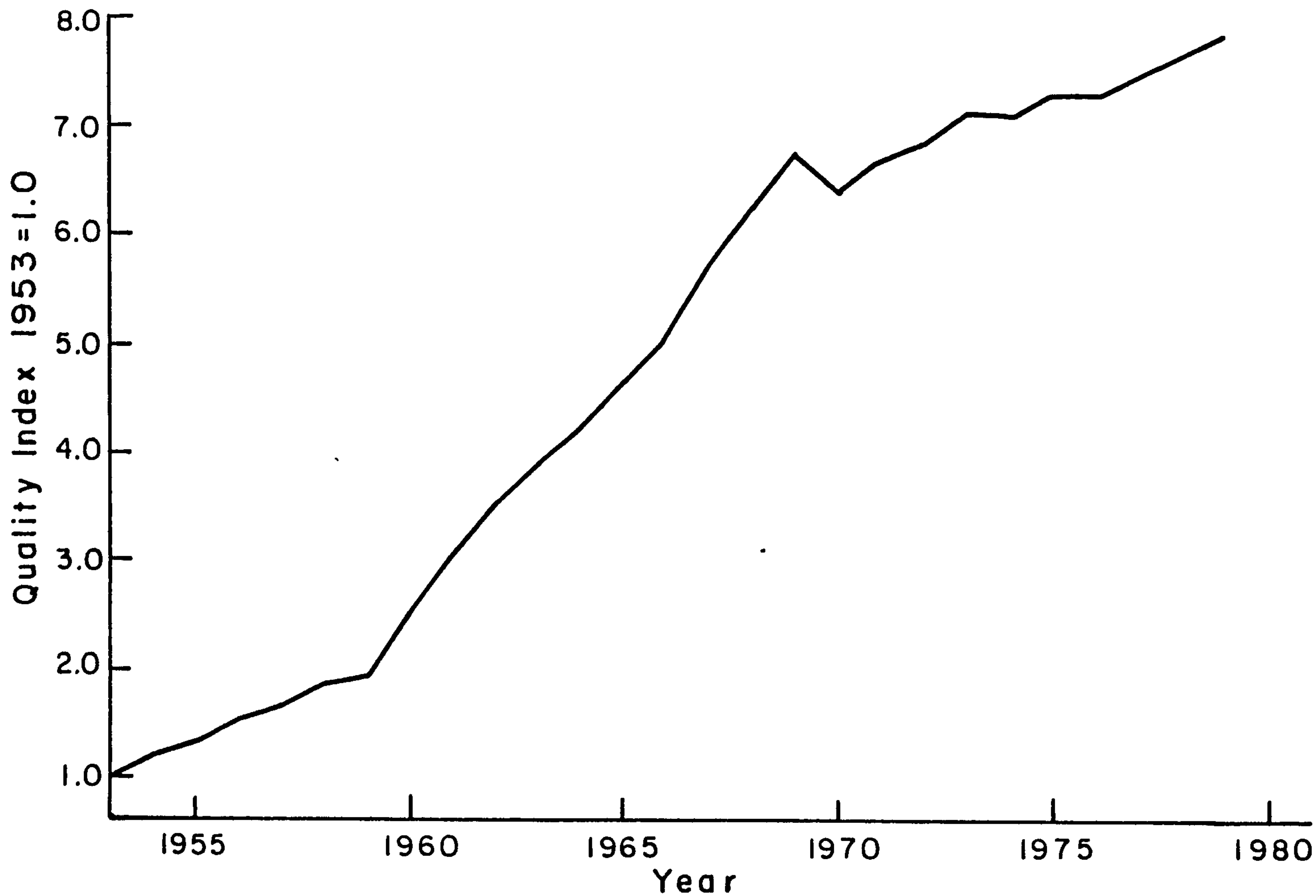



FIGURE 2 QUALITY INDEX

$Q_i$ = quality index (1 + [airborne speed$_i$ - 1953 speed]/1953 speed + [available seats per aircraft$_i$ - 1953 seats]/1953 seats + [aircraft revenue miles$_i$ - 1953 miles]/1953 miles])

yields the following statistics:

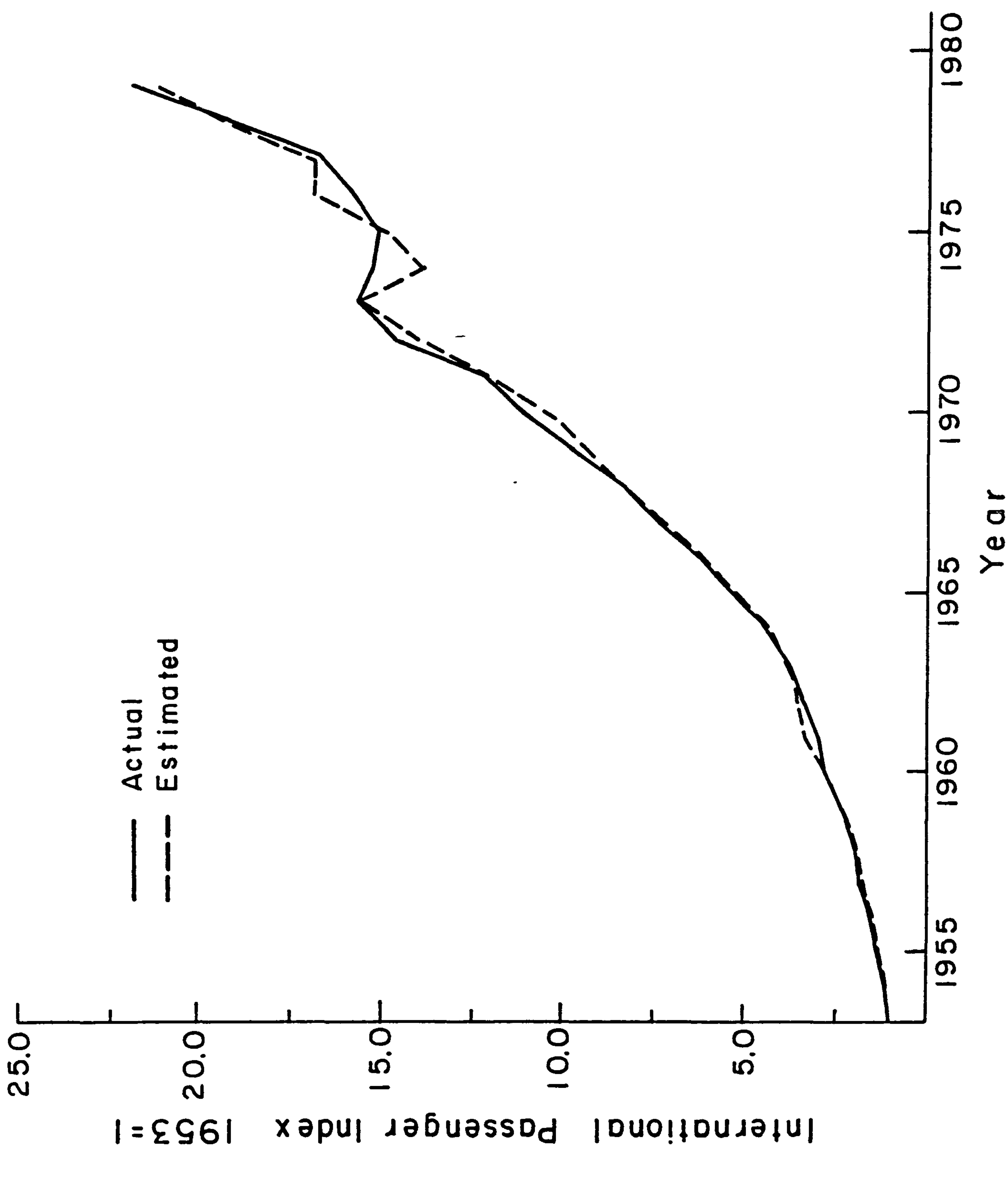
$\alpha$ = 1.065 Standard error = 0.147 T = 7.233

$\beta$ = 0.423 Standard error = 0.119 T = 3.544

The model is statistically sound. It has a good statistical fit (multiple R = 0.93). The F ratio is high (72.5). F ratio compares the explained variance (due to regression) to the unexplained variance (error sum of squares). A high F ratio generally indicates that all of the regression coefficients are not statistically equivalent to zero. The T statistics validate this point. Generally, a T statistic greater than 2.0 means that the coefficients are significant. The standard error of the estimate is low (0.052). Finally, the signs of the coefficients are correct.

The delta log equation shows percentage changes in the passenger index from one year to the next related to percentage changes in $B_i$ and $Q_i$. A comparison of actual and estimated passenger indices is shown in Figure 3. (The estimated indices are computed by yearly updates of the actual index.)

The use of the model for forecasting is subject to the usual caveats of econometric models. In addition, it should be recognized that the model omits a number of considerations. Only US GNP is used, although by 1979 about 50% of the travelers were aliens. No attempt was made to construct a weighted GNP index since, if the model were used for forecasting, a projection of many countries' economic activity would then have to be made, a dubious undertaking, as noted previously. Additionally, the economies of other major industrial nations (whose citizens make up the great majority of travelers to the U.S.) move somewhat in tandem with the US economy (although not necessarily at the same rate) and the US GNP appears to serve as an adequate proxy for all.


Actual
Estimated
International Passenger Index 1953=1
25.0
20.0
15.0
10.0
5.0
1955
1960
1965
1970
1975
1980
Year

The international passenger count includes charter passengers, while all the other variables are confined to scheduled service. Ever since the INS started keeping track of charter passengers in 1972, their percentage has remained fairly constant at only about 12% of the total traffic.

No attempt was made to separately account for charter traffic. While the price of tickets for a charter flight is generally less than that of a scheduled carrier, the pattern of yield changes for charter carriers is similar to that of the scheduled carriers (Brown, 1980).

Also neglected are travel costs that are not related to air transportation: food, lodging, entertainment, and ground transportation at the destination. Undoubtedly, the favorable exchange rates have influenced some European travelers to come to the United States (the Deutschmark, for example, has appreciated 74% against the dollar from 1972 to 1980), and conversely have caused some American tourists to shift to less expensive countries (Taneja, 1980), although this phenomenon has proved hard to quantify (Mutti and Murai, 1977). Certainly the average length of stay of U.S. travelers in Europe decreased from 27 days in 1970 to 17 in 1977, but then again this is fairly universal. It also decreased in South America from 22 days (1970) to 14 (1977), and also in other overseas areas from 28 days (1970) to 20 (1977) (Miller and Font, 1975; Bolyard, 1979).

Yields for U.S. international airlines only are used, whereas foreign airlines now carry about 50% of the traffic as well. Foreign airlines' yields are unavailable, so the question is largely moot; but since tickets cost about the same (excluding foreign exchange considerations), U.S. yields appear to be adequate as a proxy for all ticket prices. (In addition, these yields are calculated including income from tickets for Canadian and Mexican traffic, whereas Canadian border passengers are excluded from the traffic totals.)

The same problem exists regarding speed, available seats per aircraft, and aircraft revenue miles. Since foreign airlines fly equipment similar to that of U.S. airlines, U.S. numbers should be representative of all international airlines. Statistical theory, at least, does not argue vehemently against these various simplifications and omissions.

Based on this model, a nomograph can be constructed using indexed variables for GNP, yield, and quality (Figure 4). With it, is is possible to explore a range of values for the independent variables and quickly arrive at an estimate of future international travelers. No certainty of the forecasts is implied, but combining the variables in a logical manner should lead to a reasonable range of potential traffic levels.

First a set of economic assumptions is necessary. (1978 is assumed as the base year.) Given current trends, a doubling of GNP by 1986 (GNP index = 2.00) is possible; assuming it is fueled by inflation, it is likely that the yield index will keep pace with inflation (yield index = 2.00), thus maintaining the buying index at 1.00. By 1986, however, aircraft improvements may lead to higher productivity (as they have traditionally in the past), allowing the airlines to pass the savings on to the customers, perhaps holding the price increases to 50% of the inflation rate (yield index = 1.5). Aircraft improvements and changes in airline operations will also make themselves felt in the quality index. Not much speed increase is anticipated; however, some increase in the comfort level (number of seats per aircraft) and increased convenience of service through the ongoing proliferation of gateways (number of aircraft miles) can be expected (Lockheed, 1980), perhaps ranging from 10% to 30%. Figure 4 shows that if inflation is passed on to the customer and there is only a 10% improvement in quality, a four percent increase in international passengers can be expected. Alternatively, it can be seen that a 30% increase in quality and a ceiling on the yield index of half the GNP index leads to a rise in passenger traffic of over 50%.

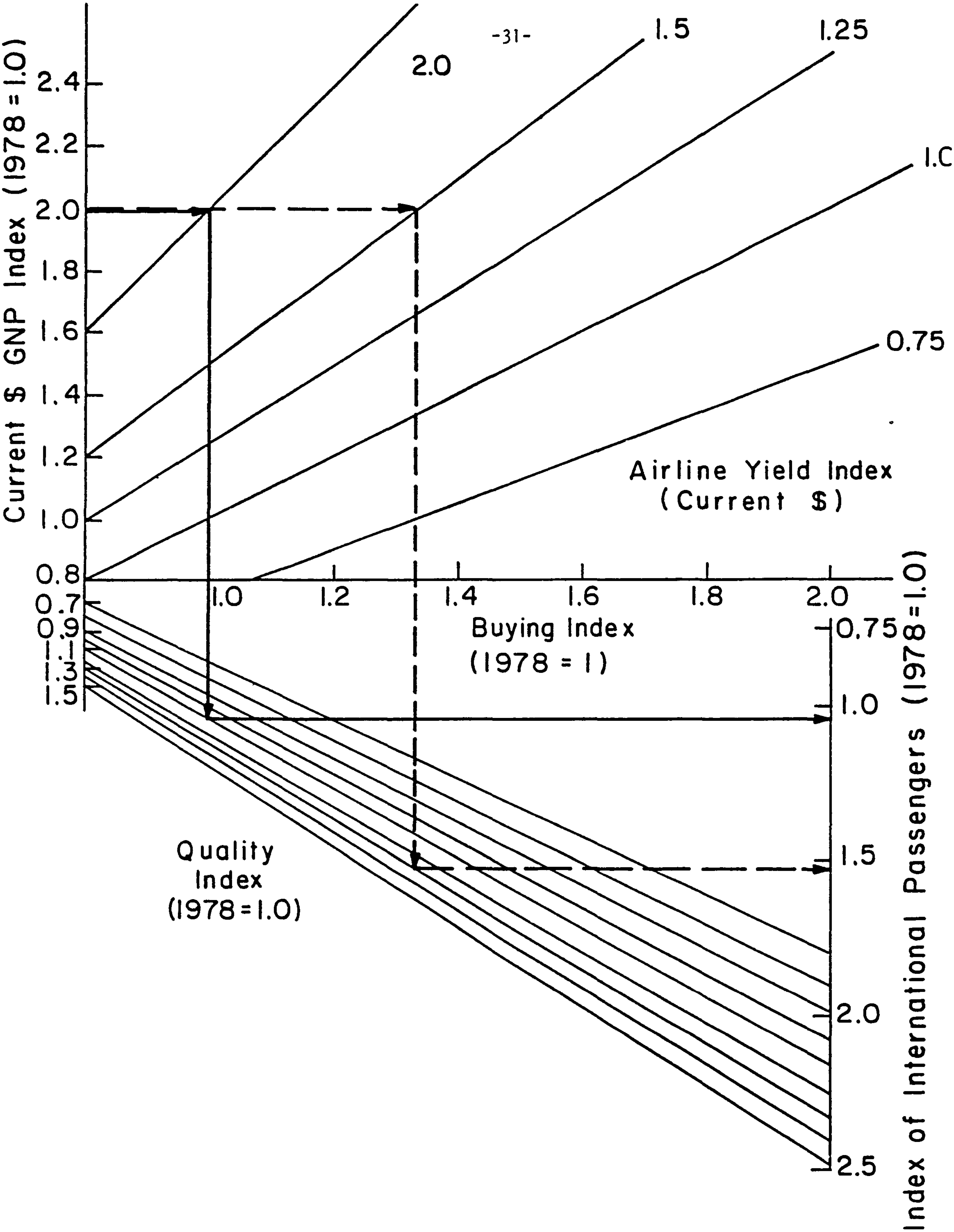



FIGURE 4 EFFECT OF GNP, YIELD AND QUALITY ON PASSENGER TRAFFIC

The nomograph lends itself nicely to exploring other options. A large supersonic aircraft introduced in large numbers would mean a substantial increase in the quality index. A return to fewer gateways would imply an increase in the number of large widebody aircraft, impacting favorably on yield and comfort, but negatively on convenience; all these scenarios can now be quickly explored.

## SECTION 4

## SUMMARY

The arguments against metrical forecasts are strong, but in the absence of certified wizards, little else but extrapolation remains. Extrapolation is generally quicker and cheaper, although it is certainly possible to get caught in expensive computational gimmickry. The real trouble with extrapolation is its philosophical barrenness: it offers only inertia as the underlying cause. Humans like to believe that they can control, to some degree, their destiny, and therein lies the attractiveness of the metrical sciences: if the cause-effect cycle of past events can accurately be identified, then it may be possible to plan ahead: either by altering the causes (policy decisions) or by coping with the expected effects by forecasting (operational decisions). Finally, just as in the physical sciences, in the social sciences as well there is a basic curiosity just to find out how things tick. However, whereas physical sciences are (fairly) deterministic, due to the inherent instability and variability of human behavior it may not be possible to predict how things will tick -- only to discover how they have ticked.

To compound the forecasting problem in aviation, the basic rules of the game are being changed. Deregulation is currently on the loose in the U.S., and efforts have been made to export it, with mixed success. Many new gateways are being opened to foreign airlines in exchange for liberal bilaterals (low fares), and foreign (and U.S.) airlines are taking advantage of this possibly transient trend. However, deregulation will probably cause the overall quality of air travel to decline, by emphasizing low yield travel to fill the empty planes, even as some observers are warning that the ever rising cost of fuel may make air transportation the province of only the rich once more (Hammarskjold, 1980).

From Table A.6 it is apparent that yield bottomed out in 1972, and following the oil price increases in 1973/74, it took four years of GNP growth before the buying index recovered to its 1973 value. As seen in Figure 2, with the introduction of the 707 into the world's international fleets, the quality index climbed steadily at about 30% per year until the 747 was put into service in early 1970. The growth of the quality index since that time has been basically in the available-seat-per-aircraft component, as more wide-bodies are flying international routes. Speed has stayed fairly constant while the miles-flown component has decreased substantially, as airlines have decreased frequency of narrow-body airplanes. The wide-bodies helped to keep the yield down as well, due to their lower seat-mile costs compensating for the fuel price increases. With fuel prices on the rise again, help from productivity gains will become harder to come by until new technology aircraft appear.

New technology aircraft will stimulate international air transportation by offering improvement in fuel efficiency to contain the rising fuel costs, but eventually this will be of limited help if fuel prices continue their upward climb. To maintain travel growth the economies of the world will have to expand faster than the yield increases to keep up the travelers' ability to buy air transportation. Finally, large, fuel-efficient, environmentally acceptable supersonic aircraft could have an impact on international air transportation somewhat similar to that of the jets; improvements in productivity and quality would once more be reflected in swiftly rising passenger traffic.

# APPENDIX

Table A.1

Concorde Passenger Data

A. Air France

| Year | Paris-Dakar-Rio Passengers | Paris-Dakar-Rio Load Factor | Paris-Caracas Passengers | Paris-Caracas Load Factor | Paris-Washington-Mexico City* Passengers | Paris-Washington-Mexico City* Load Factor | Paris-New York Passengers | Paris-New York Load Factor |
|---|---|---|---|---|---|---|---|---|
| 1976 | 12,631 | 61.7 | 2,731 | 35.9 | 12,064 | 74.1 | -- | -- |
| 1977 | 13,569 | 61.4 | 4,352 | 41.8 | 21,433 | 50.3 | 4,290 | 58.2 |
| 1978 | 12,935 | 65.8 | 4,486 | 42.2 | 10,780 | 37.3 | 47,783 | 66.6 |
| 1979 | 14,805 | 66.6 | 4,534 | 44.8 | 20,393 | 47.6 | 50,745 | 71.3 |

*Mexico added September 30, 1978

B. British Airways

| Year | London-Washington Passengers | London-Washington Load Factor** | London-New York Passengers | London-New York Load Factor** | London-Bahrein-Singapore* Passengers | London-Bahrein-Singapore* Load Factor** |
|---|---|---|---|---|---|---|
| 1976 | 11,244 | 75.0 | -- | -- | 6,443 | 42.4 |
| 1977 | 27,387 | 64.4 | 2,490 | 71.1 | 4,897 | 37.7 |
| 1978 | 12,366 | 42.6 | 64,858 | 72.1 | 6,040 | 26.7 |
| 1979 | 15,492 | 53.0 (E) | 82,280 | 72.0 (E) | 18,514 | 65.0 (E) |

* Singapore added January 24, 1979

** Load factor based on 100 seats

Table A.2

WASHINGTON - LONDON ROUTE (NON-DIRECTIONAL)

| | | Concorde | | BA 747* | PA 747* |
|---|---|---|---|---|---|
| Year | # | Passengers | Frequency per Month | Passengers | Passengers |
| 1976 | 1 | -- | -- | 6,923 | 11,158 |
| | 2 | -- | -- | 3,949 | 8,143 |
| | 3 | -- | -- | 5,922 | 9,897 |
| | 4 | -- | -- | 8,401 | 10,558 |
| | 5 | 305 | 4 | 11,724 | 13,114 |
| | 6 | 1,092 | 16 | 13,944 | 15,495 |
| | 7 | 1,432 | 19 | 16,061 | 15,660 |
| | 8 | 1,341 | 17 | 10,641 | 14,157 |
| | 9 | 1,516 | 17 | 13,417 | 13,814 |
| | 10 | 2,217 | 27 | 11,502 | 12,507 |
| | 11 | 1,832 | 25 | 4,827 | 10,110 |
| | 12 | 1,509 | 25 | 6,085 | 10,421 |
| 1977 | 1 | 1,469 | 24 | 5,004 | 11,874 |
| | 2 | 1,501 | 24 | 3,897 | 7,682 |
| | 3 | 2,079 | 27 | 5,783 | 10,731 |
| | 4 | 1,827 | 26 | 5,509 | 11,340 |
| | 5 | 2,429 | 33 | 8,118 | 6,174 |
| | 6 | 2,559 | 33 | 9,487 | 15,318 |
| | 7 | 2,626 | 37 | 9,604 | 15,200 |
| | 8 | 1,694 | 34 | 7,047 | 15,686 |
| | 9 | 3,192 | 49 | 7,397 | 13,437 |
| | 10 | 3,915 | 62 | 10,056 | 12,587 |
| | 11 | 3,006 | 52 | 5,894 | 8,397 |
| | 12 | 1,090 | 24 | 6,770 | 9,028 |

* 747 service by British Airways (BA) and Pan American (PA) from May 1976 was daily.

Washington-London Route (continued)

page two

| | | Concorde | | BA 747* | PA 747* |
|---|---|---|---|---|---|
| Year | # | Passengers | Frequency per Month | Passengers | Passengers |
| 1978 | 1 | 834 | 18 | 6,615 | 5,503 |
| | 2 | 799 | 21 | 5,025 | 8,298 |
| | 3 | 862 | 26 | 7,886 | 10,475 |
| | 4 | 989 | 25 | 9,689 | 12,042 |
| | 5 | 1,231 | 26 | 13,257 | 21,428 |
| | 6 | 1,251 | 26 | 16,011 | 10,067 |
| | 7 | 1,094 | 28 | 18,711 | 23,050 |
| | 8 | 916 | 26 | 18,071 | 21,427 |
| | 9 | 1,663 | 26 | 17,614 | 21,059 |
| | 10 | 1,405 | 28 | 15,813 | 16,338 |
| | 11 | 727 | 24 | 10,507 | 12,408 |
| | 12 | 565 | 16 | 9,323 | 13,210 |

* 747 service by British Airways (BA) and Pan American (PA) from May 1976 was daily.

TABLE A.3

U.S. - West Germany Traffic

| | TOTAL | U.S. Citizens | Aliens | U.S. Citizens Arrivals | U.S. Citizens Departures | Aliens Arrivals | Aliens Departures | U.S. Citizens Arrivals U.S. Flag | U.S. Citizens Arrivals Foreign Flag | U.S. Citizens Departures U.S. Flag | U.S. Citizens Departures Foreign Flag | Aliens Arrivals U.S. Flag | Aliens Arrivals Foreign Flag | Aliens Departures U.S. Flag | Aliens Departures Foreign Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 1,265,727 | 752,710 | 513,017 | 363,078 | 389,632 | 253,936 | 259,081 | 175,738 | 187,340 | 184,824 | 204,808 | 92,248 | 161,688 | 90,599 | 168,482 |
| 1976 | 1,571,094 | 981,128 | 589,966 | 509,679 | 471,449 | 305,254 | 284,712 | 301,580 | 208,099 | 256,814 | 214,635 | 125,702 | 179,552 | 109,161 | 175,551 |
| 1977 | 1,687,073 | 1,050,207 | 636,866 | 533,029 | 517,178 | 330,001 | 306,865 | 299,625 | 233,404 | 277,689 | 239,489 | 136,247 | 193,754 | 115,171 | 191,694 |
| 1978 | 1,859,477 | 1,075,241 | 784,236 | 544,073 | 531,168 | 418,701 | 365,535 | 266,806 | 277,207 | 257,757 | 273,411 | 168,029 | 250,672 | 133,696 | 231,839 |
| 1979 | 2,056,456 | 1,075,271 | 981,185 | 528,758 | 546,513 | 524,700 | 456,485 | 266,669 | 262,089 | 283,748 | 262,765 | 212,015 | 312,685 | 169,120 | 287,365 |

TABLE A.4

U.S. - Venezuela Traffic

TOTAL

| Year | U.S. Citizens | | | | Aliens | | | |
|---|---|---|---|---|---|---|---|---|
| | Arrivals | | Departures | | Arrivals | | Departures | |
| | U.S. Flag | Foreign Flag | U.S. Flag | Foreign Flag | U.S. Flag | Foreign Flag | U.S. Flag | Foreign Flag |
| | 402,861 | | | | | | | |
| | 164,315 | | | | 238,546 | | | |
| | 81,223 | | 83,092 | | 124,035 | | 114,511 | |
| 1975 | 50,417 | 30,806 | 48,511 | 34,581 | 55,723 | 68,312 | 50,157 | 64,354 |
| | 458,237 | | | | | | | |
| | 165,325 | | | | 292,912 | | | |
| | 76,603 | | 88,722 | | 148,601 | | 144,311 | |
| 1976 | 40,833 | 35,770 | 45,694 | 43,028 | 58,788 | 89,813 | 56,417 | 87,824 |
| | 563,817 | | | | | | | |
| | 179,120 | | | | 384,697 | | | |
| | 85,444 | | 93,676 | | 197,051 | | 187,646 | |
| 1977 | 51,794 | 33,650 | 54,651 | 39,025 | 88,243 | 108,808 | 78,715 | 108,931 |
| | 710,756 | | | | | | | |
| | 182,256 | | | | 528,500 | | | |
| | 84,148 | | 98,108 | | 271,081 | | 257,419 | |
| 1978 | 53,511 | 30,637 | 63,640 | 34,468 | 135,148 | 135,933 | 122,438 | 134,981 |
| | 854,815 | | | | | | | |
| | 190,423 | | | | 664,392 | | | |
| | 86,322 | | 104,101 | | 344,484 | | 319,908 | |
| 1979 | 54,211 | 32,111 | 67,702 | 36,399 | 181,571 | 162,913 | 165,592 | 154,316 |

Table A.5

1953-1979: Selected Statistics for International Air Travel

| Year | Passengers (000) | Per Capita Disposable Personal Income (current $) | Yield for Int'l Airlines (Current ¢/ RPM) | U.S. GNP (Billions Current $) | Airborne Speed MPH | Available Seats/AC | AC Rev. Miles (Millions) |
|---|---|---|---|---|---|---|---|
| 1953 (FY) | 1,715 | 1,571 | 6.84 | 366.1 | 229 | 52.0 | 114 |
| 4 | 1,853 | 1,574 | 6.76 | 366.3 | 240 | 56.2 | 120 |
| 5 | 2,206 | 1,654 | 6.66 | 399.3 | 244 | 56.4 | 135 |
| 6 | 2,643 | 1,731 | 6.68 | 420.7 | 248 | 58.1 | 152 |
| 7 | 3,053 | 1,792 | 6.55 | 442.8 | 253 | 61.4 | 162 |
| 8 | 3,402 | 1,821 | 6.46 | 448.9 | 255 | 63.7 | 173 |
| 9 | 4,064 | 1,898 | 6.29 | 486.5 | 263 | 67.5 | 172 |
| 1960 CY) | 4,902 | 1,934 | 6.35 | 506.0 | 307 | 89.9 | 163 |
| 1 | 5,055 | 1,976 | 6.08 | 523.3 | 357 | 108.7 | 161 |
| 2 | 5,752 | 2,058 | 5.87 | 563.8 | 394 | 118.7 | 172 |
| 3 | 6,356 | 2,128 | 5.82 | 594.7 | 423 | 124.8 | 192 |
| 4 | 7,657 | 2,278 | 5.45 | 635.7 | 441 | 127.2 | 214 |
| 1965 | 8,996 | 2,430 | 5.29 | 688.1 | 451 | 129.1 | 248 |
| 6 | 10,589 | 2,597 | 5.16 | 753.0 | 468 | 129.3 | 286 |
| 7 | 12,456 | 2,740 | 5.01 | 796.3 | 482 | 132.2 | 351 |
| 8 | 14,160 | 2,930 | 4.95 | 868.5 | 476 | 135.6 | 408 |
| 9 | 16,605 | 3,111 | 5.18 | 935.5 | 477 | 138.9 | 450 |

Table A.5 (continued)

| Year | Passengers (000) | Per Capita Disposable Personal Income (Current $) | Yield for Int'l Airlines (Current ¢/ RPM) | U.S. GNP (Billions Current $) | Airborne Speed MPH | Available Seats/AC | AC Rev. Miles (Millions) |
|---|---|---|---|---|---|---|---|
| 1970 (CY) | 18,960 | 3,348 | 5.01 | 982.4 | 482 | 154.9 | 378 |
| 1 | 20,784 | 3,588 | 5.10 | 1,063.4 | 481 | 184.0 | 351 |
| 2 | 25,020 | 3,837 | 4.98 | 1,171.1 | 480 | 190.8 | 350 |
| 3 | 26,659 | 4,285 | 5.32 | 1,306.6 | 481 | 201.5 | 361 |
| 4 | 26,055 | 4,646 | 6.39 | 1,412.9 | 481 | 213.7 | 330 |
| 1975 | 25,828 | 5,088 | 7.17 | 1,528.8 | 482 | 224.8 | 331 |
| 6 | 27,101 | 5,504 | 7.15 | 1,702.2 | 484 | 230.0 | 319 |
| 7 | 28,505 | 6,017 | 7.61 | 1,899.5 | 487 | 236.7 | 315 |
| 8 | 32,750 | 6,672 | 7.49 | 2,127.6 | 489 | 244.1 | 319 |
| 9 | 37,296 | 7,363 | 7.66 | 2,368.5 | 490 (E) | 250 (E) | 330 (E) |

Table A.6

1953-1979: Selected Indices for International Air Transportation

| Year | GNP Index | Yield Index | Ability to Buy | Convenience of Service | Comfort | Speed | Quality Index | Passenger Index |
|---|---|---|---|---|---|---|---|---|
| 1953 | 1.000 | 1.000 | 1.000 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 |
| 4 | 1.001 | 0.988 | 1.013 | 0.053 | 0.081 | 0.048 | 1.182 | 1.080 |
| 1955 | 1.091 | 0.974 | 1.120 | 0.184 | 0.085 | 0.066 | 1.335 | 1.286 |
| 6 | 1.149 | 0.977 | 1.176 | 0.333 | 0.085 | 0.083 | 1.501 | 1.541 |
| 7 | 1.210 | 0.958 | 1.263 | 0.421 | 0.117 | 0.105 | 1.643 | 1.780 |
| 8 | 1.226 | 0.944 | 1.299 | 0.518 | 0.181 | 0.114 | 1.839 | 1.984 |
| 9 | 1.329 | 0.920 | 1.444 | 0.509 | 0.225 | 0.148 | 1.882 | 2.370 |
| 1960 | 1.382 | 0.928 | 1.489 | 0.430 | 0.729 | 0.341 | 2.500 | 2.858 |
| 1 | 1.429 | 0.889 | 1.607 | 0.412 | 1.090 | 0.559 | 3.061 | 2.950 |
| 2 | 1.540 | 0.858 | 1.795 | 0.509 | 1.283 | 0.721 | 3.513 | 3.354 |
| 3 | 1.624 | 0.851 | 1.909 | 0.684 | 1.400 | 0.847 | 3.931 | 3.706 |
| 4 | 1.736 | 0.797 | 2.179 | 0.816 | 1.446 | 0.926 | 4.188 | 4.465 |
| 1965 | 1.880 | 0.773 | 2.431 | 1.175 | 1.483 | 0.969 | 4.627 | 5.245 |
| 6 | 2.057 | 0.754 | 2.728 | 1.509 | 1.487 | 1.044 | 5.040 | 6.174 |
| 7 | 2.175 | 0.732 | 2.971 | 2.079 | 1.542 | 1.105 | 5.726 | 7.263 |
| 8 | 2.372 | 0.724 | 3.277 | 2.579 | 1.608 | 1.079 | 6.266 | 8.257 |
| 9 | 2.555 | 0.757 | 3.376 | 2.947 | 1.671 | 1.083 | 6.701 | 9.682 |

Table A.6 (continued)

| Year | GNP Index | Yield Index | Ability to Buy | Convenience of Service | Comfort | Speed | Quality Index | Passenger Index |
|---|---|---|---|---|---|---|---|---|
| 1970 | 2.684 | 0.732 | 3.666 | 2.316 | 1.980 | 1.105 | 6.401 | 11.055 |
| 1 | 2.905 | 0.746 | 3.894 | 2.079 | 2.538 | 1.100 | 6.717 | 12.119 |
| 2 | 3.199 | 0.728 | 4.394 | 2.070 | 2.669 | 1.096 | 6.835 | 14.589 |
| 3 | 3.569 | 0.778 | 4.587 | 2.167 | 2.875 | 1.100 | 7.142 | 15.545 |
| 4 | 3.859 | 0.934 | 4.132 | 1.895 | 3.110 | 1.100 | 7.105 | 15.192 |
| 1975 | 4.176 | 1.048 | 3.985 | 1.904 | 3.323 | 1.105 | 7.332 | 15.060 |
| 6 | 4.650 | 1.045 | 4.449 | 1.798 | 3.423 | 1.114 | 7.335 | 15.802 |
| 7 | 5.188 | 1.113 | 4.662 | 1.763 | 3.552 | 1.127 | 7.442 | 16.621 |
| 8 | 5.812 | 1.095 | 5.307 | 1.798 | 3.694 | 1.135 | 7.627 | 19.096 |
| 9 | 6.470 | 1.120 | 5.776 | 1.895 | 3.808 | 1.140 | 7.843 | 21.747 |

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16 Abstract

International air transportation to and from the United States is analyzed. Long-term and short-term effects and causes of travel are described. The applicability of econometric methods to forecast passenger travel is discussed. A nomograph is developed which shows the interaction of economic growth, airline yields, and quality of service in producing international traffic.

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