Forecasting Air Travel Arrivals: Model Development and Application at the Honolulu International Airport

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Honolulu International Airport is one of the dozen busiest airports in the United States. It provides a port of entry for foreign flights and both domestic and interisland terminals. For Hawaii's airport engineers and planners, this status makes short- to medium-term air travel forecasts essential, particularly for landside applications. A unique model system is described with separate models for each origin region or country. The models are estimated with the Cochrane-Orcutt regression procedure. Major explanatory variables include the gross national product (GNP), gross domestic product (GDP) (in various forms), and the consumer price index (CPI). Exchange rates, strength of currencies, and variables for wars, recessions, and airline strikes are also introduced. The models adhere closely to the actual number of arrivals, and all variables perform as expected. The USA model has an overall error rate (for the 18 years of the estimation span) of less than 0.05 percent and annual extreme errors ranging from −6.4 to 5.7 percent. The Japan model also has an overall error rate of less than 0.05 percent and annual extreme errors ranging from −7.5 to 10.4 percent. Near-future values for explanatory variables can be obtained from major economic organizations, thus the use of the model system requires only that planners update variable values annually from regularly issued publications. Long-term forecasts are more difficult due to the lack of published data. In those cases, the user must resort to a combination of trend extrapolation with ARIMA, as shown in this discussion, and educated estimates based on contemporary macroeconomic literature.

The development of an air travel demand model system for Hawaii is discussed. Hawaii's airport system includes five major and several secondary airports. It is owned by the state and managed by the Airports Division of the state department of transportation (DOT). The Honolulu International Airport is one of the busiest in the nation; in 1992, it ranked ninth in the number of domestic passengers and fourth in the number of international passenger arrivals (category X airports, American Airport Traffic Report 1993).

Because Hawaii's airport system is the primary mode of passenger transportation into and out of the state, accurate demand forecasting is essential. Forecasts are used for landside planning applications (e.g., ramp control, baggage handling, pedestrian corridor level-of-service, queueing analysis at check-in counters and security points, size of holding areas, parking demand, and traffic circulation volume) and by the Airports Division as input to its Airport Landside Planning System (ALPS) software.

The research goal was the estimation of user-friendly air travel forecasting models for the Airports Division. For ease of use and reliability of forecasts, the models were estimated with macroscopic data taken from the United Nations (UN), the Organization for Economic Cooperation and Development (OECD), the International Monetary Fund (IMF), the Economist Intelligence Unit (EIU), the Pacific Asia Travel Association (PATA), and World Bank publications. Variables representing other factors affecting travel behavior (e.g., wars, exchange rates, and promotional fares) also were introduced.

Two independent concepts for model estimation were established. The first entails the estimation of global air-travel generation and the estimation of Hawaii's (variable) share of that market. This process explicitly accounts for the effects of competition and is under consideration for future investigation. The second entails the estimation of separate forecasting models for each major originating point of air travel to Hawaii. Competition is accounted for in the number of arrivals from a particular country or region. Models for arrivals from the mainland United States and Japan are presented. Arrivals from these places of origin constitute approximately 75 percent of the total number of arrivals to Hawaii.

This study is unique in its consideration of economic, demographic, and other defining characteristics of the originating regions and countries. As noted in the literature review, such a model system has not yet been developed.

This study consists of five parts. After the introduction, a literature review focusing on forecasting methodologies and destination competition is presented. Concept development and methodology (including data description and variable definitions) are then discussed, followed by an explanation of the USA and Japan models with forecasts to the year 2000. The final section presents conclusions and directions for future research.

LITERATURE REVIEW

The review of literature that follows focuses on (a) air travel forecasting methodologies (estimation procedures and model specifications) and (b) the major explanatory variables that have been used in past studies and proven useful. The review also covers destination competition. Such a discussion is appropriate for destinations with a high number of tourist arrivals. [A more detailed presentation of existing literature can be found in a thesis by the first author (*1*)].

Forecasting Literature

Although several studies to model tourism in Hawaii have been undertaken (*2,3*), none estimate demand from originating countries based on the economic and demographic variables of those countries or the competition between tourist-attracting countries.

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The Hawaii Visitors Bureau (HVB), a nonprofit organization that promotes Hawaii as a tourist destination, forecasts visitor arrivals for the short-term (i.e., for a period of 1 year). HVB uses (a) survey data from a sample of travel agents worldwide, (b) immigration records, and (c) data from continuously conducted in-flight surveys. Data from the travel agents reflect committed (not future) travel plans, and the immigration and in-flight survey data offer insights concerning the actual situation of visitor arrivals.

The Department of Business, Economic Development, and Tourism (DBEDT) uses a model (*4*) to project visitor arrivals based on assumptions about factors such as air fares and income levels, which have failed to account for the (largely worldwide) economic recession of the early 1990s and the "air-fare wars" among airlines in recent years. The DBEDT model considers the economies of the U.S.A. and Japan markets only. Markets such as Korea, the Philippines, Australia, New Zealand, Canada, and Europe are also important to Hawaii, but are not considered in the DBEDT model. The main purpose of the DBEDT model is to forecast the state's economy and act as a source of information for land transportation models and highway planning.

Stuart (*5*) used the gravity model to interpret air-passenger traffic between Hawaii and the mainland United States. The aim of this study was to test the hypothesis that air-passenger traffic is a function of distance and population distribution. The model was not used to predict the future pattern of passenger movement to Hawaii.

A review of the literature reveals that much more work on aviation forecasting has been done outside Hawaii. The objective of the model specified by Crouch et al. (*6*) was to estimate the impact of international marketing activities of the Australian Tourist Commission (ATC) on the number of tourist arrivals. Multivariate loglinear regression analysis was used to estimate the elasticities of demand by considering the economies of the United States, Japan, New Zealand, the United Kingdom, and Germany. The model includes:

- Real per-capita disposable personal income (which is used as an approximate measure of the price of tourist services in Australia);
- Air fares to Australia from the origin country;
- Promotional expenditure by the ATC;
- A trend term to allow for changing "tastes"; and
- Dummy variables to account for the effect of special conditions in certain years.

The model reflects the historical data well, but its forecasting ability is questionable given the lack of knowledge for forecasting several of the independent variables.

Armstrong (*7*) used cross-section analysis and a logarithmic model form to forecast international tourism demand. Model variables include the number of tourist arrivals recorded in country j coming from country i (dependent variable), a value that is assumed to reflect the tourist appeal of country j and which arises from factors not explicitly included in the model. Those factors include:

- Climate;
- Resorts and culture;
- The population of country i;
- The income per capita of country i [gross national product (GNP) per capita];
- A value given to the proximity of frontiers or common language, if any, between countries i and j;
- The distance between generating country i and recipient country j; and
- The value of time for n = 1963, 1967, 1975, 1980.

It is not clear how the value of time is defined.

Two base years (1963 and 1967) were considered and the model gave tourist flows for the years 1975 and 1980 between each of the 522 pairs of generating and recipient countries. The forecasts were verified by conducting a time-series analysis of the actual number of tourists generated by each origin country as a function of its population, GNP per capita, and average distance traveled abroad. Armstrong concluded that the biggest increases over the forecast period 1967 to 1980 would be in arrivals to nontraditional tourist countries (namely, Fiji, New Zealand, Australia, etc.).

Witt and Martin (*8*) examined the choice of appropriate variables to represent tourists' cost of living for various origin-and-destination countries. The model was an attempt to test whether the consumer price index (CPI) is a suitable proxy for the cost of living of tourists at the destinations. Their model attempts to explain the flow of tourists from major origin countries [namely, France (to Portugal and the United Kingdom), Germany (to Austria and Italy), the United Kingdom (to Spain and Greece), and the United States (to Canada and France)]. A loglinear model structure was used. The lost of the time-series explanatory variables includes the population and personal disposable income of each origin country; the cost of living for tourists at each destination; a weighted average of the cost of tourism in substitute destinations; the exchange rate of the currencies between each origin-destination pair; air fares; a weighted average of air fares to substitute destinations; the cost of travel by surface; and dummy variables.

The authors concluded that tourist cost-of-living data were not superior to the simple CPI or simple exchange-rate proxies. The empirical results indicated that the CPI (either alone or with the exchange rate) is a reasonable proxy for the cost of tourism (*8*).

The literature shows that the GNP, CPI, and dummy variables representing airline strikes, recessions, and exchange rates are important determinants of intercity travel.

Destination Competition

Tourism is one of the most rapidly growing sectors of the international economy. As more countries realize the importance of tourism to their economies, the competition among them will increase. The U.S. market has a large share of the world tourism market and Hawaii's potential for growth in tourism is great.

In a study of the destinations competing with Hawaii (*9*), places with the same attributes (such as sun, sand, and sea) were chosen. Additional criteria were established to narrow the list. The Caribbean, Mexico, and Australia emerged as the primary destinations competing with Hawaii.

Studies also (*10–12*) have shown that natural beauty and climate are the primary elements that attract people to a destination. Additional factors include culture, sports, shopping, and night life.

Although the potential worth of attractiveness to modeling arrivals is obvious, the incorporation of such factors in time-series models is problematic for two reasons. First, definitions of attractiveness and historical measurements of it are lacking. Elements of attractiveness that remain constant over time (e.g., the cultural value of historical sights and major museums) are not useful in time-dependent models. Elements of attractiveness that change over time

(e.g., crowding of beaches, congestion, and pollution) are useful in time-series models if (a) consistently measured over-time indices (or reasonable proxy variables) are available, and (b) future values for these indices can be forecast with reasonable confidence (i.e., easier to forecast than the dependent variable). There is a clear lack of research in this area, and to the best of the authors' knowledge, the aforementioned conditions are not met.

Second, the real issue may not be the actual quantitative assessment of a dimension of attractiveness (which could be estimated with a level of service or quality index), but its perception in various markets. Perceptions not only vary from reality, but also differ among cultural or ethnic groups. (One might ponder the perception of safety from crime in Los Angeles by Tokyo and New York City residents). Thus, perceptions add another layer of difficulty to an already difficult problem.

Because the goal of the research was to estimate a set of robust and user-friendly models for engineering and planning applications, and because of the issues discussed in this section, indices of attractiveness were not used.

METHODOLOGY

Model Structure

The initial modeling concept focused on the estimation of global air-travel generation, followed by the estimation of Hawaii's (variable) share of the international market. This process explicitly accounts for the effects of competition. The estimation of a global air-travel generation model is still at the conceptual level because the collection of global tourism data is difficult and good definitions of competing destinations are not available. Theoretically, all tourist destinations compete for visitors. The authors do not agree that only destinations with sun, sand, and sea, as concluded in the study conducted for the DBEDT by Arthur Young, Inc. (*9*), compete with Hawaii. Many Americans may decide to visit Europe instead of a seaside resort when the dollar is strong and the air fares to Europe are similar or less expensive than those for Hawaii. Besides the Caribbean, Mexico, and Australia (*9*), Florida and California are formidable competitors (particularly for families with children), not only because of lower total air fares, but also because of the abundance of family-oriented theme parks in those states. For similar reasons, other destinations in the Pacific (e.g., Indonesia, the Polynesian islands, Singapore, and Thailand) should be included when considering Asian markets. Thus, the problem of destination competition becomes complex and impossible to address with the scarce, often incompatible, and short-span time-series data available (n.b., properly adjusted and defined macroeconomic statistics are not available before the 1980s for several countries).

The actual approach for model development involved a model system with separate forecasting models for each major origin country (or region) of air travel to Hawaii. Competition is partly accounted for in the dependent variable, which is the number of arrivals from the particular country or region. It cannot be presumed, however, that preferences represented in the dependent variable will be perpetual. Hence, forecasts beyond a 5- to 10-year period should consider destination competition explicitly, or the models and their estimates should be updated regularly. (Specifically, the models were designed for forecasts up to 10 years and with the stipulation that the coefficients will be updated annually; hence continuously "corrected" forecasts can be obtained for sensible short- and medium-term planning applications).

Finding accurate time-series data of arrivals from a given region or country is a major challenge because the arrivals often include travelers who made a connection at the region. For example, most visitors to Hawaii from Hong Kong, Taiwan, Singapore, and China arrive via Tokyo. Therefore, sources that apply the appropriate screenings (from travel agent bookings and on-board surveys) were selected for the collection of arrival data. Specifically, arrival data from 1974 to 1983 were taken from PATA reports (*13*), and data from 1983 to 1992 were obtained from HVB publications.

The generic structure of the models is given as

$$ARRIVALS^i_N = ARRIVALS^i_{N-1} \cdot (1 + \%CHANGE^i_{N-1 \text{ to } N})$$

$$\%CHANGE^i_{N-1 \text{ to } N} = f(\text{GDP or GNP, CPI, CURRENCY EXCHANGE, STRIKE, WAR, AIR FARE, } \ldots)$$

where

$ARRIVALS^i_N$ = visitor arrivals in year N, for country or region i;
$ARRIVALS^i_{N-1}$ = visitor arrivals in year $N - 1$, for country or region i;
$\%CHANGE^i_{N-1 \text{ to } N}$ = model estimate of the percent change from year N to $N - 1$, for country or region i; and
$f(\text{GDP}, \ldots)$ = model specification (the list of explanatory variables in each model is presented later).

The following steps were part of the process of model development:

1. Data collection and selection of variables,
2. Estimation of alternative model specifications and statistical testing, and
3. Model refinement and selection.

Estimation Procedure

The equations were initially estimated using the ordinary least squares method. In all cases the Durbin-Watson (DW) statistic indicated the presence of autocorrelation; thus, the parameter estimates were inefficient and the regression assumptions were not valid. The models were reestimated using the Cochrane-Orcutt iterative procedure to reduce the likelihood of autocorrelation. The following criteria were used to arrive at the final models:

1. Correct signs for the coefficients: the GNP-GDP variable should have a positive sign, the CPI variable should have a negative sign, the exchange rate coefficient should be positive, and the dummy variables should have logical signs.
2. DW statistic: a DW statistic lying between 1.8 and 2.2 is used as a measure for no autocorrelation. A DW statistic equal to 2 indicates the absence of autocorrelation (*8*).
3. t-statistic and R^2 value: the statistical significance of parameter estimates and the ability of the model to explain a large portion of the variance of the dependent variable are important indicators of goodness-of-fit. However, models with the highest R^2 were not nec-

essarily selected as best if other criteria were violated. Also, variables with not-significant parameter estimates were retained when a reasonable justification was available.

Explanatory Variables

Several mostly macroeconomic variables were considered in the model specifications. Figure 1 presents several variables pertaining to the USA model. The dollar index of relative strength to a number of foreign currencies reported by the Chicago and New York currency markets (monthly futures) shows that, at times when the dollar is strong (e.g., 1984 and 1985), a decrease in arrivals is observed as foreign travel becomes more affordable. Conversely, when the dollar index dropped sharply in 1986, a sharp increase in arrivals to Hawaii was observed.

The annual change in arrivals and in the CPI show roughly opposite trends, as expected. Low inflation promotes discretionary expenditures such as vacations, whereas high inflation (e.g., 1978 to 1980) curtails them.

The annual change in arrivals and in the per-capita GDP show similar trends. A strong economy generates business and discretionary travel. Economic declines (e.g., 1987 to 1990) and recessions (e.g., 1981 and 1990) have a strong detrimental effect, which often lags by 1 year. For example, the poor economic performance in 1979 resulted in a decrease in arrivals in 1980.

Certainly, air travel is a multifaceted (multivariate) phenomenon; thus, a consistent correlation between arrivals and macroeconomic variables is not observed. As shown in the next section, however, the developed specifications (which include several of the aforementioned variables) result in a model that explains more than 75 percent of the variance of the dependent variable.

The list of variables used in the specifications of the USA model follows.

LLGDPC = Annual change of the gross domestic product per capita in percent; performed best in a logarithmic transformation and lagged. Specifically:

LLGDPC = $0.75 \cdot \text{Log}(GDPC_{N-1}) + 0.25 \cdot \text{Log}(GDPC_{N-2})$

Thus, the per capita product of up to 2 years before the target year affects arrivals. The parameters of 0.75 and 0.25 were obtained with a trial-and-error process with values from 0 to 1. The combination shown yielded the best model fit.

CPI = Annual change of the consumer price index.

STRIKE = Dummy variable to account for the United Airlines strike in 1985; this event caused a significant drop in visitors to Hawaii given that United's approximate market share in Hawaii is 30 percent.

NATURE = Dummy variable to account for the devastation caused on Kauai by Hurricane Iniki.

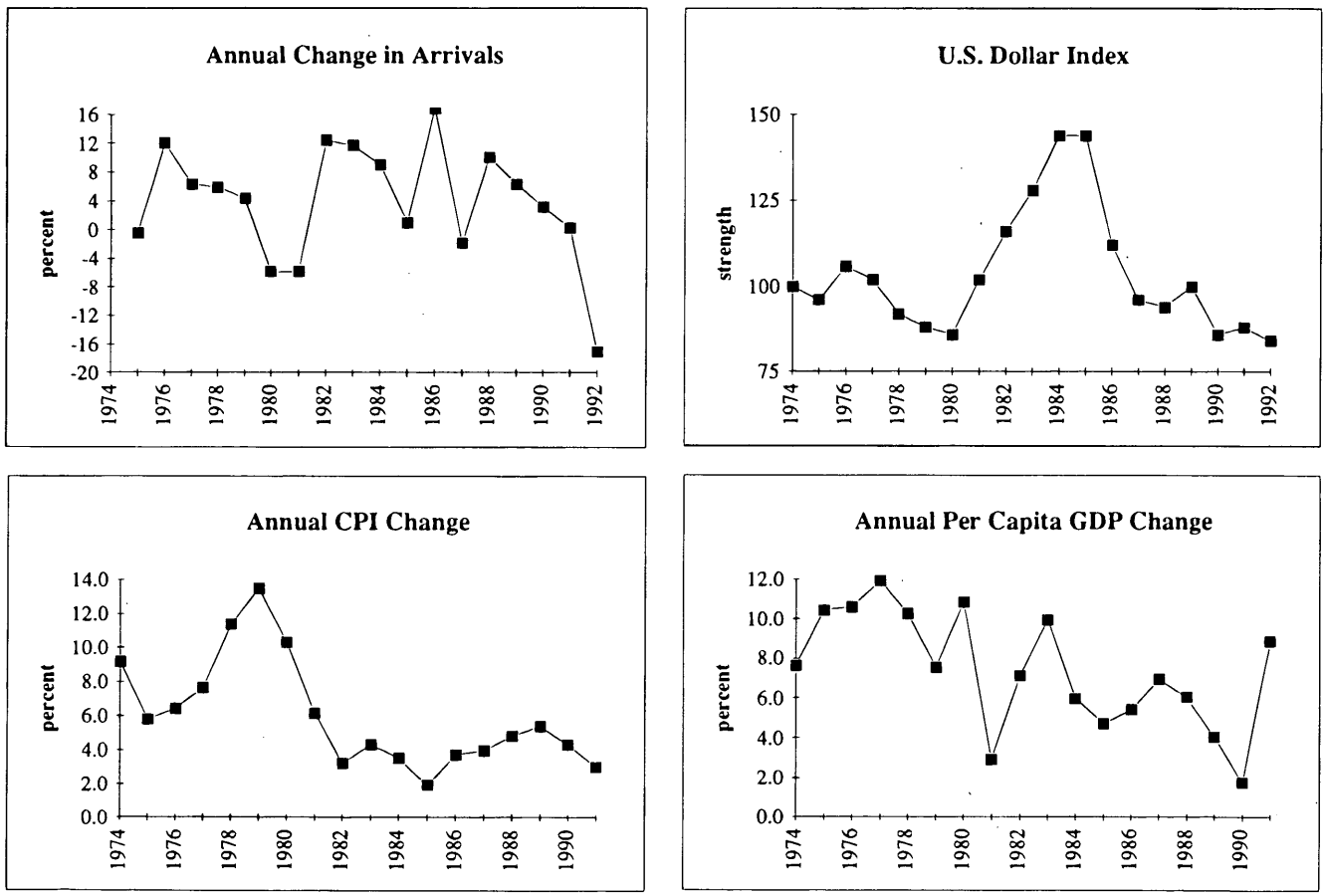

FIGURE 1 Trend of arrivals from the mainland United States and selected factors affecting them.

DJIA = Dummy variable based on the widely publicized Dow Jones Industrial Average index (DJIA) and used as a proxy of "economic mood." A positive economic (and spending) mood is assumed (value of +1) when the index gains 100 or more points within a year (difference between the last and first trading day for the year); a negative mood is assumed (value of −1) when the index loses 100 or more points in a year; and a neutral mood is assumed (value of 0) when the index gains or loses fewer than 100 points in a year. The use of this (and similar) indices may be particularly appropriate for high-cost destinations, which are afforded by mostly higher-income households, many of which are likely to be investors and, thus, will follow the economy's progress represented by the DJIA.

Variables tested but excluded from the final specification included:

1. The annual change in the gross state product (GSP) of the state of California. It was observed that when the annual growth of California's GSP drops below 3 percent, a decrease in arrivals is observed. California is a very important market for Hawaii, partly because of its market size, proximity, least-expensive air fares, and frequent service. Ultimately, a separate model for the West Coast is sought, but the procurement of arrival data that do not include stopovers in that region so far has not been possible.
2. The Persian Gulf war of 1991.
3. A dummy variable to account for years when the U.S. dollar is particularly strong (e.g., 1984 and 1985).
4. A variable based on Department of Commerce statistics on year-over-year change of disposable incomes in the United States.
5. A variable based on the average annual price of a barrel of crude oil.
6. Values of air fares, both current and constant, were used with little success, partly because air fare increases (and decreases in the early 1990s) follow the fluctuations in demand. In addition, the large proportion of frequent-flier seats used for travel to Hawaii further distorts the picture of air travel cost.

Figure 2 presents two major variables included in the Japan model and the dependent variable. The arrivals from Japan and the GNP show similar trends; for example, in the years of GNP decline (1983 and 1986), arrivals also decline. The only inconsistency in the two trends is the span between 1975 and 1979, when GNP growth declines but arrivals increase (partly because of the yen's strength). As a result, a dummy variable (J75–79) was introduced to account for the inconsistency, which can ultimately be explained by a lack of vacation time and the unlikelihood of foreign travel, both of which have changed substantially since the early 1980s, at least in Japan's urban centers.

The yen index serves as a signal to growth in arrivals from Japan. When a large gain in the exchange rate is observed, arrivals increase. Conceivably, large increases in the value of the yen vis-à-vis the dollar "make the news" in the Japanese market, which responds positively when an attractive product (a vacation or wedding in Hawaii) becomes more affordable in yen.

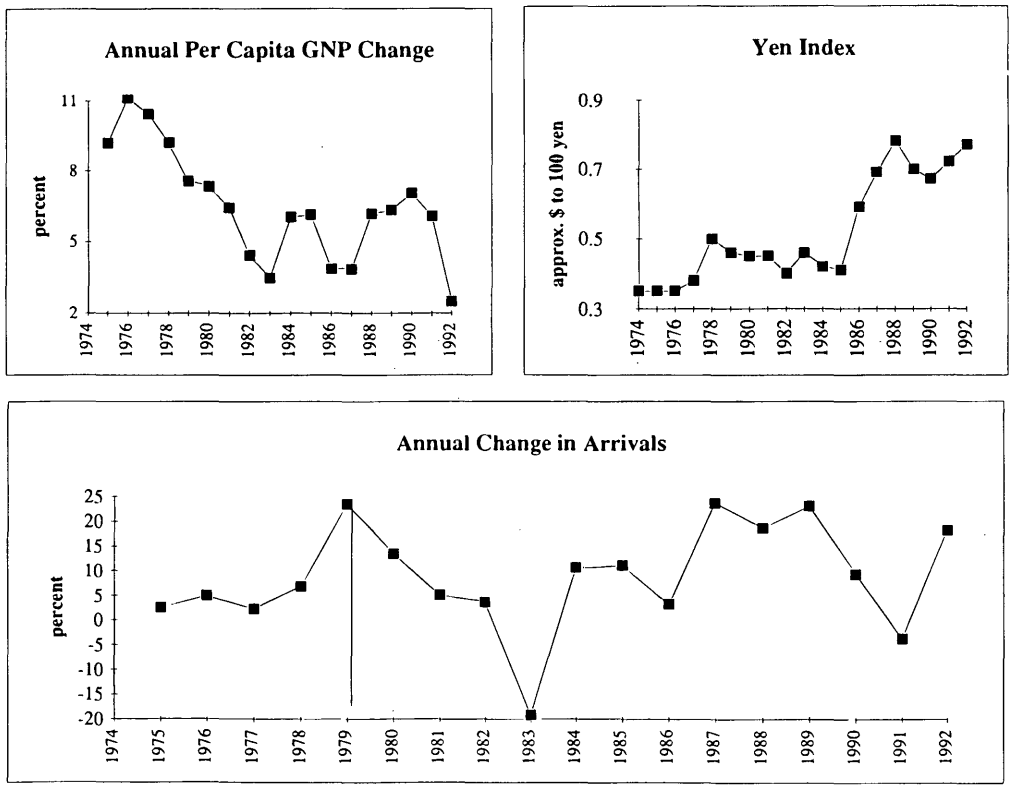

FIGURE 2 Trend of arrivals from Japan and selected factors affecting them.

The recent sharp recession in Japan tends to be confined to certain real estate and financial markets ("bubble, or overvalued economy") and has not affected the majority of the public. To the contrary, various economic reports suggest that falling prices and lowered inflation have made the recent recession a period of opportunity for most middle-class citizens of Japan.

The variables used in the specifications of the Japan model are:

LLGNPC = Annual change of the GNP in percent; performed best in a logarithmic transformation, and lagged for 1 year ($LLGNPC_{N-1}$).

YEN = Dummy variable to account for large increases in the strength of the ¥: 1 in 1979, 1987, 1988, 1989, and 1992, 0 for all other years (taken from historical futures charts of the Commodities Research Bureau); performed best when lagged for one year (e.g., the large increase in 1978 affects the 1979 arrivals due to advance bookings).

WAR = Dummy variable to account for the Persian Gulf war: 1 for 1991, 0 for all other years.

RECESSION = Dummy variable to account for the recessions in 1983 and 1991.

J75–79 = Dummy variable to account for the "cultural habit" of little vacation and foreign travel before the 1980s. For this period, contrary to logical expectations based on economic trends (see Figure 2), foreign travel from Japan was low and roughly constant, although Japan's economy was growing vigorously.

Variables tested but excluded from the final specification included:

1. The consumer price index at 1985 prices, and
2. The NIKKEI index (similar to the DJIA used for the USA market).

The fit was not successful partly because NIKKEI 225 index statistics before 1984 are not available.

MODEL ESTIMATION

The USA Model

The trend of arrivals shows that arrivals from the mainland United States increased for most years until 1991 (Figure 3, top). There was a slight decrease from the years 1979 to 1981. An economic recession in most parts of the country in late 1990 and early 1991 caused a sharp decrease from the mainland United States in 1992. Additional reasons for the decrease are the recession in California and the turbulence in the airline industry, which became a disincentive for travel to Hawaii because of the lowering of fares to most vacation destinations, excluding Hawaii (*14*). The final model estimated with the Cochrane-Orcutt procedure is shown in Equation 1.

	β *parameter*	*t-statistic*
$\%CHANGE^{USA}_{N-1\text{ to }N} =$	− 8.50	[1.23]
	+30.82 · *LLGDPC*	[2.86]
	− 2.17 · *CPI*	[4.61]
	−16.09 · *STRIKE*	[3.54]
	−12.64 · *NATURE*	[2.20]
	+ 4.00 · *DJIA*	[2.73]

$R^2 = 0.91$, adjusted $R^2 = 0.84$, $DW = 1.9$ (1)

All the variables are statistically significant at the 95 percent level (except for the intercept) and perform as expected. The GDPC has a positive impact on the arrivals whereas the CPI has a negative effect. The dummy variable for strike has a negative impact, the performance of the stock market has a positive impact, and the effects of Hurricane Iniki are negative, all as expected. The plot of the predicted arrivals corresponds with the actual arrivals. The Durbin-Watson statistic value of 1.9 indicates that autocorrelation is not a threat to the validity of this model. The standard error of estimate is 4.18, which is about half (51 percent) of the standard deviation of the dependent variable.

The Japan Model

The trend of arrivals shows that the arrivals from Japan increased moderately until the year 1986 (Figure 3, bottom). The years from 1986 onward display a steep increase except for 1991, which shows a decrease in the arrivals. The final model estimated with the Cochrane-Orcutt procedure is shown in Equation 2.

	β *parameter*	*t-statistic*
$\%CHANGE^{JAPAN}_{N-1\text{ to }N} =$	− 4.28	[0.46]
	+13.65 · *LLGNPC*	[1.16]
	+18.26 · *YEN*	[6.16]
	− 7.87 · *WAR*	[1.28]
	−15.36 · *RECESSION*	[3.37]
	− 5.65 · *J75–79*	[1.18]

$R^2 = 0.87$, adjusted $R^2 = 0.78$, $DW = 2.0$ (2)

YEN and *RECESSION* are strongly significant, but the other variables demonstrate a significance at the 80 percent level only. All the variables perform as expected. It is evident that large fluctuations of the yen's strength affect the exchange rate accordingly, thus making foreign travel more (or less) attractive to visitors from Japan. The plot of the predicted arrivals corresponds with the actual arrivals. The Durbin-Watson statistic value of 2.03 indicates that autocorrelation is not a threat to the validity of this model. The standard error of estimate is 5.08, which is about half (54 percent) of the standard deviation of the dependent variable.

Based on the models' ability to reflect the historical arrival patterns, the following results summarize the estimation accuracy. The worst 1- and 5-year underestimates for the USA model were −6.4 and −2 percent, respectively. The worst 1- and 5-year overestimates for the USA model were +5.7 and +1.5 percent, respectively. The error for the total period between 1975 and 1992 was 0.046 percent. The worst 1- and 5-year underestimates for the Japan model were −7.5 and −1.2 percent, respectively. The worst 1- and 5-year overestimates for the Japan model were +10.4 and +2.8 percent, respectively. The error for the total period between 1975 and 1992 was 0.046 percent.

Forecasts

Forecast models 1 and 2 can be made in the following two ways.

1. Short-term predictions of arrivals can be done using data published by major organizations. Specifically, forecasts for the GDP and the CPI in the USA model can be input according to growth rates reported by the OECD (*15*) and the EIU (*16*). The GNP growth rates for the Japan model can be taken from the EIU. Population forecasts for most countries can be taken from the United Nations (*17*).

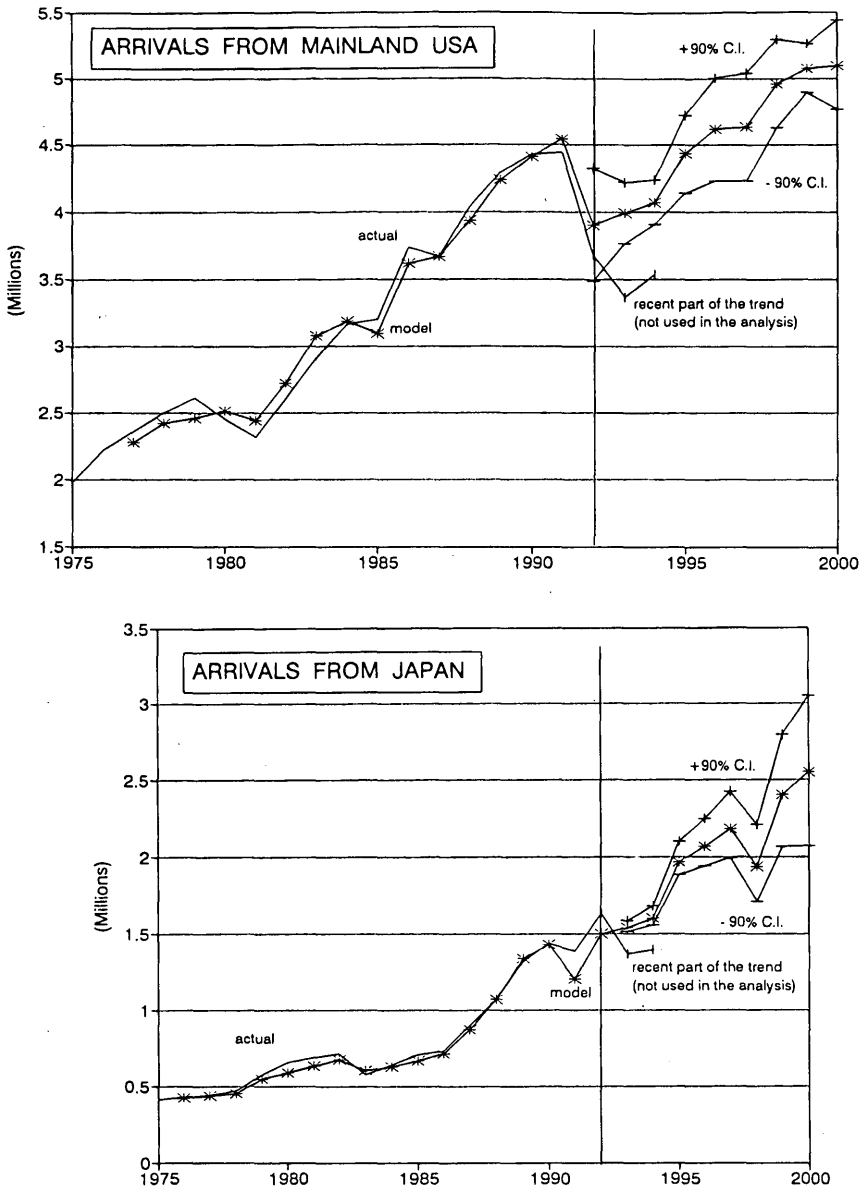

FIGURE 3 Actual arrivals, forecasts, and confidence intervals for two major origins of travel to Hawaii, the mainland United States (top), and Japan (bottom).

2. For longer-term forecasts, the user must resort to a combination of trend extrapolation with ARIMA and educated estimates based on contemporary macroeconomic literature basically because, beyond two years, macroeconomic forecasts are erratically documented and often unavailable. The forecasts presented in Figure 3 are based entirely on ARIMA applications. After extensive trial-and-error specifications, the best-fit ARIMA models were USA-GDP (1,1,0), USA-CPI (1,0,0), and Japan-GNP (1,0,0). Forecast values for the dummy variables were assigned so that the 1993-to-2000 average matches the 1975-to-1992 average.

ARIMA modeling enables the estimation of confidence intervals. The 90 percent-level confidence intervals are shown in Figure 3 for the forecast portion of the models. The recent trend of arrivals from the mainland United States and Japan (years 1993 and 1994) are also depicted in Figure 3. These values were not included in the model estimation process and are shown here for comparison.

The USA model could not account for the large decline in arrivals in 1993. A reversal of that drop in arrivals occurred last year and economic analysts expect travel to Hawaii to increase (*18*). Actual arrivals are expected to return to the rates depicted by the forecast.

The decline in arrivals, particularly in 1993, can be attributed partly to a drop in airline seating capacity (lift) from the mainland United States to Hawaii. Lift levels were approximately 7,600,000 in 1990, 7,200,000 in 1991, and 5,600,000 in 1993 (*18*). The corresponding load factors were 63 percent in 1990, 63.5 percent in 1991, and 67.5 percent in 1993. Although supply clearly exceeds demand, the increasing load factors and reduced number of scheduled flights in peak seasons are likely to cause seat reservation difficulties for potential visitors, and ultimately the abandonment of trips to Hawaii

for those who have little time flexibility. A reason for the reduction of lift levels is given in the Bank of Hawaii's *Annual Economic Report* (*18*): "Much of the contraction of air service has arisen from airline concern with 1.2 billion mi of unredeemed frequent-flier claims. Not surprisingly, frequent fliers are more apt to redeem their miles on travel to Hawaii than they are on flights to the destinations on which the mileage was originally accumulated, so that Hawaii becomes an unprofitable destination for the carriers."

A notable narrowing of the confidence intervals appears for 1994 and 1999 in the USA model. The reason is that the GDP and CPI have opposite signs for those years and, by coincidence, the errors largely canceled each other.

The Japan model corresponds remarkably well with actual arrivals. However, the overall forecast may be somewhat optimistic. This is because the ARIMA forecast of the GNP assumes that the trend of a rapidly growing Japanese economy will continue. Reports in the financial press, however, state that Japan is less likely to sustain as rapid a growth as in the past due to tightening worldwide competition, the easing of trade barriers, and a partial loss of the pricing advantage on several durable products. Thus, the near-term forecasts for Japan should be based on published GNP forecasts, and the longer-term forecasts should be revised frequently.

CONCLUSIONS

The goal of the research was the development of a short- to medium-term econometric model system for forecasting air travel arrivals for the Hawaii DOT. The target use of the forecasts is landside planning applications. The model system is developed from readily available information, enabling the Airports Division to use it with no more effort than annual visits to the library to collect updated data. Models for the United States and Japan have been developed using the Cochrane-Orcutt regression estimation procedure. Similar models for Australia, Canada, Germany, Korea, New Zealand, and the United Kingdom were developed recently and are presented elsewhere (*19*).

Various diagnostic tests were conducted to arrive at the final models. All the explanatory variables perform as expected. The per-capita GDP (GNP for Japan) had a positive effect on arrivals, whereas the CPI had a negative effect. Large fluctuations of the yen's strength affect arrivals from Japan. The effect of the airline strike of 1985 was considerable. The effects of war (uncertainty, fear of terrorism, etc.) were shown to suppress foreign travel. The coefficient estimates reflect that the Persian Gulf war had a negative impact on arrivals from Japan. The USA model shows that arrivals also are sensitive to the trends in financial markets.

The models correspond remarkably well to the actual number of arrivals, and all independent variables perform as expected. The USA model has an overall error rate (for the 18 years of the estimation span) of less than 0.05 percent. Annual extreme values of error range from −6.4 to 5.7 percent. The Japan model also has an overall error rate of less than 0.05 percent. Annual extreme values of error range from −7.5 to 10.4 percent.

Potential improvements to these models would entail the consideration of other variables, such as the airline seat capacity to Hawaii and the tourist attractiveness of Hawaii (which may be declining as the state becomes more crowded, the hotels older, etc.). The model also can be estimated using monthly arrivals to account for seasonal effects.

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REFERENCES

1. Kawad, S. *Aviation Forecasting at the Local Level: Theoretical Development and Application at the Honolulu International Airport.* M.S. thesis. Department of Civil Engineering, University of Hawaii at Manoa, Honolulu, Hawaii, March 1994.
2. *The Hawaii Econometric Model and its Applications.* Department of Business, Economic Development and Tourism, Honolulu, Hawaii, 1983.
3. *Domestic Market Report* (also *Foreign Market Report*). Hawaii Visitors Bureau, Honolulu, Hawaii, 1991.
4. *Revised Long-Range Economic and Population Projections to 2010: State of Hawaii (Series M-K).* Department of Business and Economic Development, Preliminary Report, Honolulu, Hawaii, 1988.
5. Stuart, M. M. *The Use of Gravity Model in Interpreting Air Passenger Traffic Between Hawaii and the Coterminous United States.* Thesis. Columbia University, New York, N.Y., 1968.
6. Crouch, G. I., L. Schultz, and P. Valeiro. Marketing International Tourism to Australia. *Tourism Management,* June 1992.
7. Armstrong, C. W. G. International Tourism: Coming or Going, The Methodological Problems of Forecasting. *Futures,* June 1972.
8. Witt, S. F., and C. A. Martin. Econometric Models for Forecasting Tourism Demand. *Journal of Travel Research,* Vol. 25, No. 3, 1987.
9. Arthur Young, Inc. *A Report on Tourism Destinations Competing with Hawaii.* Department of Business and Economic Development, Honolulu, Hawaii, 1989.
10. Liu, J. C., and J. Auyong. Tourist Attractiveness of Hawaii by County. Travel Industry Management, *Tourism Research Publications,* No. 10, University of Hawaii, 1988.
11. Ritchie, J. R. B., and M. Zins. Culture as a Determinant of the Attractiveness of a Tourism Region. *Annals of Tourism Research,* April/June 1978.
12. Gee, C. Y., J. C. Makens, and D. J. L. Choy. *The Travel Industry.* Van Nostrand Reinhold, 1989.
13. Pacific Asia Travel Association (PATA). *Annual Statistical Report, 1991.*
14. Bank of Hawaii. *Annual Economic Report,* Vol. 42, 1992.
15. Organization for Economic Cooperation and Development. *OECD Economic Outlook,* Paris, France, 1993.
16. *Country Report.* The Economist Intelligence Unit, London, 1994.
17. *World Population Prospects,* 1992 revision, United Nations, New York, 1993.
18. Bank of Hawaii, *Annual Economic Report,* Vol. 44, Honolulu, Hawaii, 1994.
19. Prevedouros, P. D., R. Uwaine, and P. An. *Origin-Specific Visitor Demand Forecasting at the Honolulu International Airport.* Presented at 7th World Conference on Transport Research, Sydney, Australia, July 1995.

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