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The Impact of Airport Use Agreement on Airport Profitability and Efficiency

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I. Introduction:

The airport privatization in Western Europe, Latin America, and Asia have created new opportunities to deal with the issues of airport efficiency and profitability. During the period which state and local governments are experiencing mounting budget deficit, economics of airport self containment attracts many attentions.

According to Federal Aviation Administration (FAA), in 1995 there were a total of 575 airports with scheduled air service in the United States; among them were 29 large hubs, 40 medium hubs, 63 small hubs, and 412 Origin-destination airports[1]. Unlike the general aviation airports (GA) which are owned by private operators, most of the commercial airports are owned by the counties, and municipal governments.[2] Economists and policy makers occasionally argued that airports provide pubic goods through aiding national defense, and contribute to regional and national economic development. Therefore, the commercial airports should be operated as a non-profit-entity with an objective to maximize benefits to the local economy. The opposing view, which is not popular with the airlines, encourages an airport operator to seek the financial viability of the airport, and charge the users the fair market share of the cost services they use.

In this paper, the authors provide a comprehensive review of airport- airlines financial agreement, and develop an analytical model to measure financial performance of the U.S. airports.

II. Airport Financial Management:

The U.S. commercial airports do not espouse similar financial agreement with the airlines. The financial and contractual agreement of a commercial airport with the airlines it serves is presented in a document known as "airport use agreement"[3]. The agreement defines how the risk, responsibilities , and reward of running an airport should be shared among the airports and airlines. The airport- airline financial relationship at the nation's major commercial airports is based on the following approaches with profound ramification for airport pricing and investment practices (Graham 1992) . These contracts stipulate the terms and the conditions governing the airlines' use of an airport and delineate the rules for calculation of the compensation airlines must

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[1] AAAE (1996) Survey of Airport Rates and Charges, Alexandria, VA: American Association of Airport Executives.

[2] In the United States, only a few commercial airports are owned by the State government.

[3] Congressional Budget Office, Financing U.S. Airports in the 1980s (Washington D.C.: U.S. Government Printing Office, 1984) 18-37.

pay for use of airport facilities and services, and identifies the airlines' rights and privileges (Lim 1980).

1. The Residual Cost Approach: under this agreement the airlines collectively assume significant financial risk by agreeing to pay any costs of running the airport that are not allocated to other users or covered by non-airline sources of revenue. So, the airlines agree to keep the airport financially self-supporting by making up any deficit remaining after the costs identified for all airport users have been offset by non-airline sources of revenue[4].

2. The Compensatory Approach: contrary to residual cost methodology, the airport operator assumes the major financial risk of running the airport and charges the airlines fees and rental rates set so as to recover the actual costs of the facilities and services that they use. Numerous airports have adopted many different versions of the compensatory approach[5]. Many residual airports have indicated a desire to move toward a more compensatory approach to airport financing.

3. The Hybrid Approach: this method combines both residuals and compensatory methodologies. For example, the agreement at the Washington airports have revenue-sharing element. At the end of each year, the profit or loss from all the airport operations including commercial facilities is spilt between the airport authority and the airlines. The profits assigned to the airlines will be put towards off-setting the next year's fees.

4. Privatization: Following BAA's successful privatization of seven airports in the London area, it has been argued that privatization of airports could generate the needed funds through private investment[6]. Under this concept, the airport is sold off to the public at large and their shares are freely traded on stock markets[7]. These agreements have significant impacts on airport financing, pricing practices, and airport productivity.

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[4] Based on residual cost approach the airside revenue is not dependent upon the volume of traffic at the airport.

[5] See Congressional Budget Office (1984), Financing US Airports in the 1980s, Washington DC: Government Printing Office.

[6] In 1987, British Airport Authority (BAA) was sold to the public for about $2 Billion on London stock market. As a result ownership of several major airport including Aberdeen, Edinburgh, Glasgow, Gatwick, London Heathrow, Prestwick, and Stansed transferred to the private hands.

[7] Pressures to privatize airports are growing, partly because governments are reluctant to go on funding airport development themselves when they feel that airports have the financial strength to raise their own capital needs.

To fund the activities, airport operator derives revenue from two principal sources.
By comparing these methods, one can recognize that the airport privatization, compensatory, and hybrid agreements would allow airports to accumulate enough residual earnings for future airport developments. This in turn helps financially strapped municipalities.

III. Airport Revenue and Expenses:

Total revenues of an airport are frequently divided into two principal categories:

1. Operating Revenues. Operating revenues are earnings that are directly associated with the running and use of the airport, including the operational areas, terminals, leased areas, and grounds (Doganis 1992). Operating revenues include all income to the airport that is directly related to volume of aeronautical activities [8,9].

2. Non-Operating revenues consist of all income from activities which are not directly related to aeronautical activities.

Airport expenses can be likewise classified into operating and nonoperating expenditures.

1. The operating expenditures of an airport are those expenditures incurred in the course of running the airport. These expenditures can disappear if the airport operation is closed down[10].

2. Nonoperating expenditures are those expenses incurred even if no operations are carried out[11].

Table 1 presents an statistical summary of airport revenue, expenses, and enplanement for large, medium and small hub airports as of 1996. For the large hub airports, the average operating expense is $ 4.675 per passenger. The operating revenue for the large hub airports is $7.266 per

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[8] Operating revenue includes: landing area revenues, terminal area concessions, and airline leased areas.

[9] U.S. airport average charges to airlines was $6.60 per enplanement in 1992. The U.S. airlines were charged more at foreign countries airports(Lewy, Loney, and Williams 1993).

[10] These expenditures are typically grouped under: - Traffic handling and commercial activities - Salaries, administration expenses, and transport expenses.

[11] Interest payments on outstanding capital - Amortization on fixed assets, fees for various nonoperating purposes.

passenger. For the medium hub airports, these figures are $3.371 ,and $5.792 respectively.

The contribution margin at large hub airports is generally greater than for medium and small hub airports. There are a number of factors that explain higher contribution margin at large hub airports, including, higher landing fee, and higher passenger traffic base.

Table 1: Airport Revenue, Expenses, and Enplaned Passengers:

Hub Size	Average Landing Fees (per 1,000 lbs glw)	Air carrier Revenue ($/pax)	Operating Revenue ($/pax)	Operating Expenses ($/pax)	Enplaned Passengers (Range)
Large:	Signatory $1.793 Non-signatory $2.002	$4.370	$7.266	$4.675	more than 5,834,195
Medium:	Signatory $1.191 Non-signatory $1.420	$2.262	$5.792	$3.371	1,458,549 to 5,834,195
Small:	Signatory $1.087 Non-signatory $1.319	$2.452	$6.387	$4.838	1,458,549 to 291,709

Source: American Association of Airport Executives: Survey of Airport Rates and Charges: 1995-96.

IV. Theoretical Model:

In this section, we explicitly develop a model to present a relationship between airport services and their corresponding prices. The model would provide us with a list of arguments influencing airport services. The model is similar to a standard revenue maximization technique. If the airport operator sells his services at fixed prices, his revenue is given by:

$$R = \sum_{i=1}^{2} P_i Q_i \tag{1}$$

To solve the constrained-maximization problem of an airport operator who desire to maximize revenue, we may form thefollowing Lagrangian function:

$$Max\ L=\sum_{i=1}^{2} P_iQ_i-(F+\sum_{i=1}^{2} VC_i)+\lambda_1[\sum_{i=1}^{2} P_iQ_i-(F+\sum_{i=1}^{2} VC_i)]+\lambda_2(Q^1-Q_1)+\lambda_3(Q^2-Q_2) \quad (2)$$

Q_1 = is the quantity of aeronautical services provided by the airport operators
Q_2 = is the quantity of non-aeronautical services provided by the airport operators
VC_i = The total variable cost to the airport operators.
F = airport's fixed cost.
Q^1 = aeronautical capacity
Q^2 = non-aeronautical capacity
λ = Lagrangian multiplier

The first order conditions are;

$$\frac{\partial L}{\partial Q_1} = P_1-\frac{\partial VC_1}{\partial Q_1} + \lambda_1(P_1+Q_1*\frac{dP_1}{dQ_1} - \frac{\partial VC_1}{\partial Q_1})-\lambda_2 = 0 \quad \textbf{(3)}$$

$$\frac{\partial L}{\partial Q_2} = P_2-\frac{\partial VC_2}{\partial Q_2} + \lambda_1(P_2+Q_2*\frac{dP_2}{dQ_2} - \frac{\partial VC_2}{\partial Q_2})-\lambda_3 = 0 \quad \textbf{(4)}$$

In order to derive the prices charged by an airport operator for aeronautical services as well as non-aeronautical, we solve the above equations for P_1, and P_2 (Henderson and Quandt, 1971)[12].

$$P_1=(\frac{\partial VC_2}{\partial Q_1})\frac{[(1+\lambda_1)+\lambda_2]}{1+\lambda_1(1+\frac{1}{\varepsilon_1})} \quad (5)$$

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[12] The second order condition requires that the relevant bordered Hessian determinant be positive.

$$P_1 = \left(\frac{\partial VC_2}{\partial Q_1}\right) \frac{[(1+\lambda_1)+\lambda_2]}{1+\lambda_1\left(1+\frac{1}{\varepsilon_1}\right)} \qquad (5)$$

$$P_2 = \left(\frac{\partial VC_1}{\partial Q_2}\right) \frac{[(1+\lambda_1)+\lambda_2]}{1+\lambda_2\left(1+\frac{1}{\varepsilon_2}\right)} \qquad \mathbf{(6)}$$

Most U.S. airports use non-aeronautical revenues to off-set total airport expenses before setting the landing fees. These airports charge as much as the market could bear for the concessionary operations. This cross-subsidization would lead to over-utilization of the airfield facilities. The U.S. airports use aircraft weight as the basis to price their airfield facilities and services. While the weight base approach is not effective for congested and over utilized airports it may be appropriate for airports which are underutilized. Currently the prices charged to use U.S. airports do not reflect the full costs of using the facilities (Doganis 1992). To use airports more efficiently, the multiple pricing system, based on peak and off-peak take offs and landings, could be used. The multiple pricing strategy ensures that those who value the limited airport facilities are the ones given access to them and thus pay a higher fee. Peak hour pricing for the airfield facilities may alleviate the congestion at many over-utilized airports.

V. **Data and the Empirical Results:**

The data used in this paper was obtained from the bi-yearly publication *Rates and Charges Survey*, published by the American Association of Airport Executives (AAAE). The years for which data was used were 1987-1988, 1989-1990, 1991-1992, 1993-1994, and 1995-1996. The data groups used include:

- Enplanement (PAX): Enplanements are the actual physical Enplanement or deplanement of passengers and do not include no-shows.

-Air Carrier Operations (LT):Air Carrier Operations are the number of times that an air Carrier makes a full operation consisting of one landing and one take-off.

-Air side Revenue (AR):Total Air side Revenue is the revenue received from landing fees, fuel taxes, gate fees and any other fees or charges directly or indirectly related to gate use for the purpose of air transport of passengers.

-Total Operating Revenue (OR): Total Operating Revenue is the total of Air side Revenue, Land side Revenue and any Subsidies received.

-Land side Revenue (LR): Land side Revenue is the revenue received from concessions, rental fees of airport offices and stores, Hotel revenues (when hotel is owned by airport), Hotel rent (when hotel building is rented to a hotelier) and any other direct or indirect revenues received from non-air transport activities.

- Operating Expense (OX): Operating Expense is the total of all out-flows for Air side and Land side operations.

In what follows, we selected the following equations for each of the three different types of airport-airlines use agreements.

$$OPR = f(PAX) \quad (7)$$
$$OPX = g(PAX) \quad (8)$$
$$PAX = h(GTS) \quad (9)$$

In order to find the best results, we estimated the model using ordinary least squares (OLS). The models tested include linear and logarithmic functions. Enplaned passengers are used as the explanatory variable. The estimated equations revealed very low Durbin-Watson statistics. A solution to the problem was attempted by estimating the auto-correlation coefficient, $\hat{\rho}$ = 1-DW/2, and transforming the original observations to remove the auto regressive scheme from the variables. Table 2. presents the estimated coefficients for our three groups of airports. Equations 7,8, and 9 are estimated using cross-sectional data for periods of 1992-1993[13].

Residual Airports:

As will be shown in the next section, the logarithmic function is found to explain the relationships better than the linear model. In both models the R^2 and Durbin Watson are very significantly in favor of the fitness of the non-linear model. The regression results for the airports under study is given by Table 2.

All the coefficients have the expected sign and are highly significant. The coefficient of independent variables imply that residual airports are getting an additional revenue of $4.02 per passenger enplaned, and the cost of handling an additional passenger is about $3.39. Therefore, the marginal contribution is about $0.63 per enplanement at residual airports.

The results also indicate that a one percent increase in passenger enplanements would increase the total operating expenses by 0.80 percent, and operating revenue by 0.855. The plot of total operating revenues against total enplanements is shown in Figure 1.a. The marginal expense, as indicated by the explanatory variable coefficient, is $3.48 per enplanement. The plot of total operating expenses against total enplaned passengers is shown in Figure 1.b. The marginal percentage of expense increase, as indicated by the explanatory variable coefficient, is 0.66 percent

[13] A total of 93 airports, 18 large air traffic hubs, 23 medium traffic hubs, and 51 small air traffic hubs, have responded to the authors survey of 250 commercial airports.

per percentage. A plot of total operating revenues and operating cost against enplanements are shown in Figures 2c and 1.c.

Compensatory Airports:

In both models the explanatory variables have the correct sign and are significant at the 0.005 level or better. The R^2s for the non-linear model exceed that of the linear model, hence, the non-linear model is a better fit. The coefficient of 6.17 for the explanatory variable implies that compensatory airports are making $6.17 per passenger enplaned. The results also indicate that the cost of handling an additional passenger is about $4.06 per enplaned passenger. Consequently, compensatory airports enjoy a marginal contribution of $2.11 per enplanement. Table 3 shows the results for compensatory commercial airports.

The coefficient of 223 for the explanatory variable in the linear model using the dependent variable air carrier operations implies that compensatory airports will incur an added expense of $223 per air carrier operation added. From the model in which passengers enplaned is dependent to total operating expenses the explanatory variable shows that an increase of one percent in the number of passenger enplanements will lead to a 0.68 percent increase in total operating expenses.

The break-even analysis for the airports are presented graphically. Figures 2a. illustrates the total revenue function, Figures 2b, the total cost function, and Figures 2c, a composite graph showing both functions. The point where the two functions intersect represents the level of operations where total revenue and total cost are equal. For all points to the left of the break-even points the cost function has a value greater than the revenue function. To the right of the break-even point (PAX= 14.75 million), revenue is greater than cost, and the vertical distance represents the profit at a given level of operations.

According to our regression results, the airport use agreement has a primary effect on airport gate utilization. The relationship between the number of daily departures per gate, and enplaned passengers per gate is illustrated in Table 4. All the coefficients have the expected sign. The results indicate that the air carrier gate use is higher for compensatory airports. The explanatory variables are significant at the 0.005 level, except for the constant. In most of the regression models, it could be seen that the value of R^2 lies between 0.50 and 0.73. A number of other factors may affect airport gate utilization[14]: aircraft size, average stage length, market share, and availability of airport gate facilities.

The number of enplaned passengers is another measure of gate utilization. The coefficient of 144,774 for the explanatory variable suggest that the marginal product of an additional gate at the residual airports is about 144,774 passengers, compared with 196,464 for the compensatory airports.

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[14] See, Linda J. Perry, "An Evaluation of Air Carrier Gate Use at Selected Airports," Handbook of Airline Economics, The McGraw-Hill Company.

Hybrid Airports:

In both models the R^2 and Durbin Watson are very significantly in favor of the fitness of the non-linear model. The explanatory variable for an air carrier operations increase of one percent will lead to a 0.48 percent increase in total operation expenses. The results also show with high confidence that a one percent increase in total passenger enplanements will result in a 0.65 percent increase in operation expenses. The results on Table 2 and 3 show that the residual airports incur greater cost for both air carrier operations and passenger enplanements ($263 and 0.77% respectively), than that of compensatory airports ($223 and 0.68 respectively). It is clear from the regression models that the form which provides the best fit changes based on the dependent variable for both residual and compensatory airports, whereas the non-linear form is best for the hybrid airport in both cases. A one percent addition to the number of passengers enplaned at the hybrid airport is expected to generate a marginal cost of 0.65 percent of operating expenses. The marginal cost of an additional one percent increase in air carrier operations is expected to be 0.48 percent of present air carrier operations.

The trend toward compensatory agreement is supported by the data. The residual airports ranked number one in both passenger enplanements and aircarrier operations in 1993. In 1996 these airports enplaned 1.9 million fewer passengers, while compensatory airports enplaned 400,000 more passengers than in 1993. Hybrid airports experienced a slight decrease in both enplaned passengers and aircarrier operations during the above period.

VI. Summary of Finding

Airport use agreement appears to have considerable influence on the airport profitability and capacity utilization. In general compensatory airports have a higher marginal contribution than residual airports. Many residual airports have indicated a desire to move toward a more compensatory approach to airport financing. Under this agreement, an airport is better able to assume the risks without relying on break-even guarantees by the airlines. In the U.S. the airport pricing is not based on economic considerations alone. Many airports set their prices based on many other factors such as social, economical, and political objectives. For airside pricing, many airports use revenue from other sources to off-set total airport expenses before setting the landing fees. This cross-subsidization seems to be more for the residual airports than compensatory ones. The marginal contribution for the residual airports is about $0.63 per enplaned passenger. For the compensatory airports, this figure is about $2.11 per enplaned passenger. The difference in contribution margin indicates that compensatory airports are able to charge higher prices per enplaned passenger. Each additional passenger enplaned at the residual airports is expected to generate marginal revenue of $4.02 while the compensatory airports are expected to generate marginal revenue of $6.17. The residual airports charge less for airfield activities than that of compensatory airports . It is clear from the regression models that the non-linear form would provide a better fit than the linear model. The marginal contribution for the hybrid airports is about $3.29 per enplaned passengers. Average gate use at compensatory airports is generally higher than for residual cost airports.

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Table 2: Regression Results for U.S. Commercial Airports*.

Functional Relationship	Airport Agreement	Dependent Variable	Constant	Independent Variable: PAX	R^2	Durbin-Watson Statistics
Linear	Residual Airports	Operating Revenue	9808071 (4.52)	4.02 (19.78)	0.69	1.52
	Compensatory	Operating Revenue	7251592 (1.85)	6.17 (13)	0.43	1.77
	Residual Airports	Operating Exp.	5314125 (2.61)	3.39 (18)	0.65	1.61
	Compensatory	Operating Exp.	6140534 (2.01)	4.06 (11)	0.35	1.74
Log-function	Residual Airports	Operating Revenue	-5.71 (1.67)	0.855 (29)	0.35	1.15
	Compensatory	Operating Revenue	3.74 (10)	0.87 (26)	0.84	1.49
	Residual Airports	Operating Exp.	4.43 (10)	-25.2 (1.32)	0.81	1.43
	Compensatory	Operating Exp.	3.37 (11)	6.83 (35)	0.73	1.73

* The numbers presented within brackets beneath each coefficients are the t-statistics.

Table 3: Air Carrier Gate Utilization by Agreement*.

Agreement	Functional Relationship	Dependent Variable	Constant	Independent Variable Gates	R^2	Durbin-Watson Statistics
Residual	Linear	Enplanement	-1916342 (3.64)	144774 (21)	0.71	1.58
		Operations**	44504 (3.66)	1838 (6.64)	0.50	1.40
Compensatory	Linear	Enplanement	-623818 (2.31)	196464 (29)	0.78	1.75
		Operations**	2001 (0.44)	2769 (25)	0.73	2.25

* The numbers presented within brackets beneath each coefficients are the t-statistics.
** Number of departures and landings.

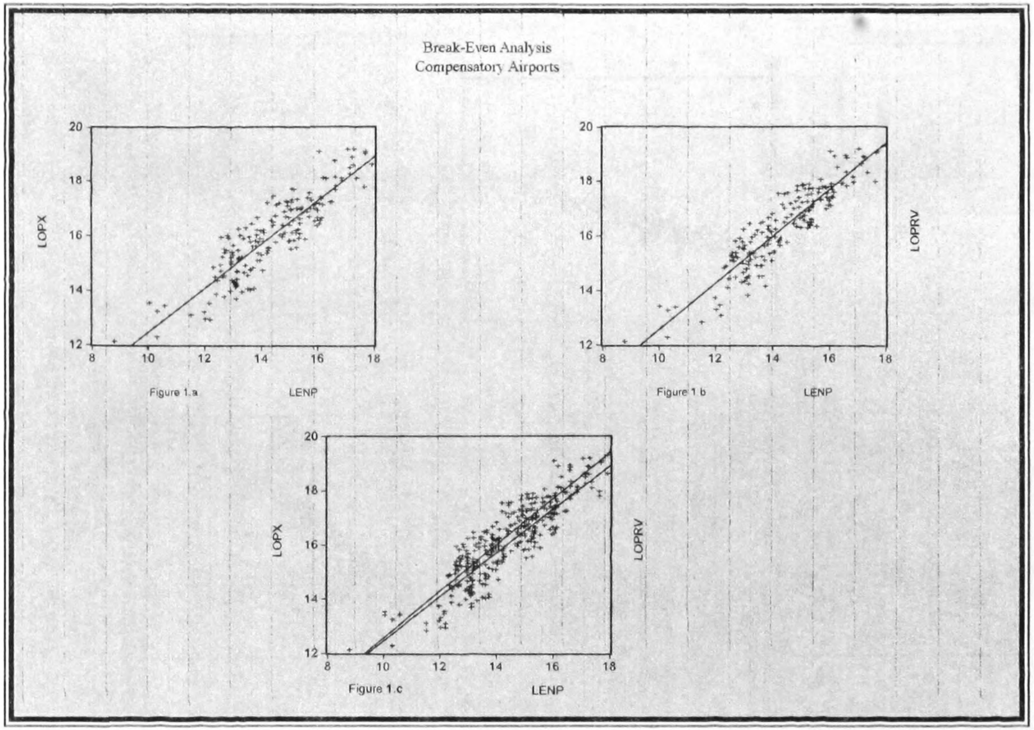

Figure 1 Residual agreement

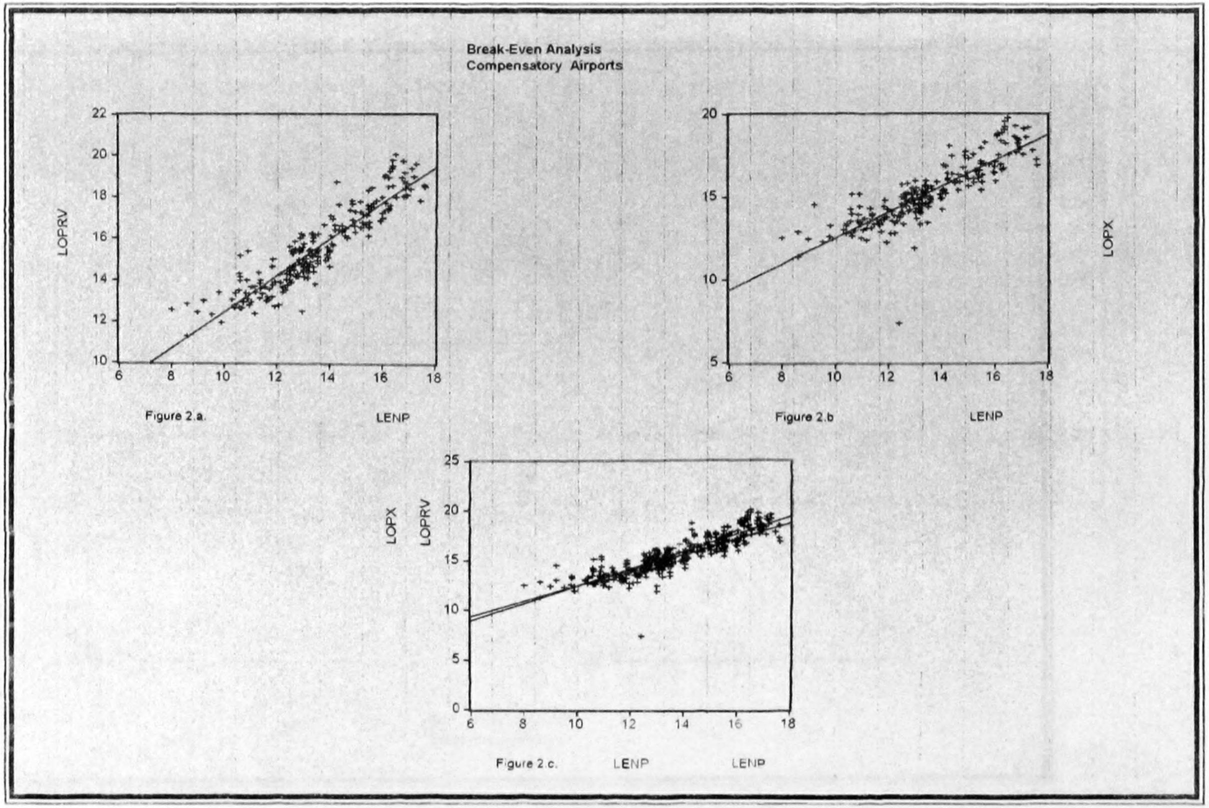

Figure 2 Compensatory Airports

1995 - 1996 AIRPORTS VS. PASSENGER ENPLANEMENTS AND AIRCARRIER OPERATIONS