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COMPETITION FOR HUB DOMINANCE: SOME IMPLICATIONS TO AIRLINE PROFITABILITY AND ENPLANEMENT SHARE

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ABSTRACT

The phenomenon of airline competition for hub dominance in terms of frequency concentration has been on the rise since deregulation. Using cross-sectional time-series data, this study explores the impact of hub dominance on airline profitability and enplanement share at the hub airport. The regression analysis finds a significant positive relationship between airline profitability and hub dominance. The relationship between an airline's share of passenger enplanements and its hub dominance seems to follow an S-curve indicating that high frequency shares are associated with even higher enplanement shares, and conversely.

INTRODUCTION

Deregulation has led to radical changes in airline network planning. A main focal point for these changes has been the greatly increased emphasis on "hubbing." All carriers have sought to build up their previous hubs, and in many cases have created new ones.

The hubbing phenomenon has been the subject of many studies. Kanafani and Ghobrial (1982) studied the relationship between the economies of aircraft size and airline hubbing. In 1985, they expanded their analysis to assess the impact of airline hubbing on airport congestion and its implications to airport economics. Kanafani and Hansen (1985) showed that, when all other variables (such as stage length, aircraft capacity, network size, etc.) are controlled airlines with strong hubbed route systems incur roughly the same cost to provide a given amount of transportation as those with less hubbed systems. Ghobrial and Sousa (1987) investigated some airline strategies to dominate their main connecting hubs.

Toh and Higgins (1985) attempted to test whether there exists a positive and strong relationship between airline hubbing and profitability. They developed two indices for airline hubbing and profitability for 17 airlines in 1982. The regression of the hub index on the profitability index showed a very poor fit and the independent variable (hub index) seemed to be statistically insignificant. Toh and Higgins (1985) also commented that profitability is not guaranteed by hub netwrok centrality, which is contrary to popular belief.

This paper is an attempt to extend the work of Toh and Higgins to explore further the impact of hub dominance on airline profitability and its passenger enplanement share. The findings of Toh and Higgins together with the results of this study will help shed some light on the commonly held belief that hubbing leads to more successful and profitable operations (see Aviation Week and Space Technology, November 1981). The paper begins by discussing the phenomenon of airline hubbing and hub dominance. This is followed by exploring the relationship between profitability and hub dominance using regression analysis. The second phase of this paper assesses the impact of hub dominance on airline share of passenger enplanements at the hub airport. The paper concludes with some implications to airline network planning, congestion at major hubs, and the public policy towards airline mergers.

TRENDS IN AIRLINE NETWORK CENTRALITY AND HUB DOMINANCE

A comparison of airline networks of today with those of the mid 1970s amply demonstrates that hubbing has increased. The now familiar pattern of multiple links emanating from a handful of hub airports has replaced the seeming hodge-podge that characterized many route systems under regulation.

One indication of a hubbed network is the concentration of operations at a few airports which serve as transfer points for connecting traffic. Measures of concentration of an airline's operations can therefore serve as measures of the degree of hubbing of that airline's route network. One such a measure is the one-airport concentration

Table 1
<u>**Operational Statistics for Selected Airlines in 1980**</u>

Airline	Main hub	Hubbing index *	hub dominance index *	airline ranking at main hub	profit index ** %
AA	ORD	0.146	26.80	2	-3.50
AL	PIT	0.189	63.04	1	9.47
BN	DFW	0.321	37.82	1	-5.70
CO	DEN	0.252	26.30	3	-5.28
DL	ATL	0.224	46.40	1	5.42
EA	ATL	0.208	41.19	2	0.47
FL	DEN	0.225	34.14	1	7.49
NW	MSP	0.156	41.09	1	2.12
OZ	STL	0.205	32.36	2	-0.34
PA	MIA	0.141	21.99	2	-8.97
PI	ROA	0.081	99.50	1	6.62
RC	ORD	0.066	15.39	3	1.53
TW	STL	0.140	41.94	1	-1.85
UA	ORD	0.164	43.61	1	-1.55
WA	LAX	0.170	25.07	2	-3.62

* Estimated using data from "Airport Activity Statistics of Certificated Route Air Carrier", U.S. Department of Transportation, The Federal Aviation Administration, 1980.

** Estimated using data from "Air Carriers Financial Statistics", Civil Aeronautics Board and the U.S. Department of Transportation, 11980

ratio which is defined as the ratio of the airline's departures from its main hub to the total aircraft departures from all airports within the airline's domestic system. This ratio will be referred to as the hubbing index. For a complete hub-and-spoke network structure (i.e.; all spoke cities are connected only to the hub airport) the number of aircraft operations (i.e.; take-offs and landings) at the hub airport is equal to the number of aircraft operations at all other airports. The hubbing index is, therefore, equal to 0.5 for a complete hub-and-spoke network structure. The trend of the hubbing index for some selected airlines' distributions of scheduled departures for the years 1976, 1978, 1980, 1982, 1984 and 1986 was estimated.

For the purpose of illustration, **Table 1** depicts this trend for the selected airlines in 1980. Overall, the time-series data suggest an upward trend in the hubbing index. The few instances of downward movement are likely due to large scale network expansions, which naturally tend to reduce concentration.

A parallel phenomenon to airline hubbing is hub dominance. While hubbing measures network centrality within the airline's system, hub dominance measures airline concentration relative to other airlines operating at the same hub. An airline's dominance index at a particular hub could be estimated as the share of that airline's departures of the total aircraft departures by all airlines from that hub. This index can also serve as a proxy for hub monopoly. The hub dominance index was calculated for all airlines under investigation at their main connecting hub over the period 1976-1984. Only domestic operations were considered for airlines offering both domestic and international services such as Pan Am, TWA, Northwest, etc. **Table 1** reports the hub dominance index (in percentages) for the airlines under in 1980. Also depicted in **Table 1** is the airline's ranking at its main connecting hub in terms of the number of aircraft departures. An analysis of the time-series data of airline ranking at major hubs over 1976-1984 indicates that airlines have exploited the opportunities of free entry and exit of deregulation and attempted to dominate the hubs which they use as funnel and transfer points for their passengers.

Hub dominance appears to be highly instrumental in establishing a strong regional identification among passengers which is important for marketing the airline. Examples are Delta at Atlanta, American at Dallas/Fort Worth, TWA at St. Louis, and Continental at Houston. In addition, a dominant airline at a particular hub can reap the monopoly profits in the markets served by that hub. Since the monopolist can alter the supply of flights and set the price (i.e.; airfare), monopoly profits in this case are usually larger than those attained under highly competitive conditions.

HUB DOMINANCE AND AIRLINE PROFITABILITY

The analysis of airline profitability is a complex one that involves a number of factors including network structure, hub dominance, fleet type and average aircraft size, stage length, average yield, route monopoly, load factor, degree of unionization, and management skills. For the purpose of this study, we will attempt to test the hypothesis that there exists a positive and strong relationship between airline profitability and hub dominance. The profitability index is estimated by dividing operating income (i.e., operating revenue-operating expense) by the operating revenue and multiplying it by 100 to be expressed in percentage terms. A profitability index is calculated for all the airlines under consideration. **Table 1** shows the estimated profitability index for these airlines in 1980.

The Model

The relationship between airline profitability and hub dominance is expressed as a linear regression model which takes the following form:

Equation 1

$$PROF_i = \alpha + \beta DOM_i + \tau FIRM_i + \theta(Y78) + \mu(Y80) + \phi(Y82) + \delta(Y84) + \sigma(Y86) + \epsilon \qquad (1)$$

Where $PROF_i$ is the profitability index in percentage terms of airline i, DOM_i is its hub dominance index in percentage points at the main hub, and $FIRM_i$ is a firm-specific variable which takes on the value one for airline i and zero otherwise with Pan Am (PA) as the control carrier. Y78, Y80, Y82, Y84 and Y86 in **Equation 1** are dummy variables for the year with 1976 as the control year (e.g.; Y80 takes on the value one for observations in 1980 and zero otherwise.) α, ß, τ, Θ, μ, ϕ, δ, and σ are the coefficients to be estimated and ϵ is the error term. Note that the inclusion of a firm-specific variable FIRM in the model is intended to capture the effects of other variables influencing the carrier's profitability. This is useful when analyzing cross sectional data.

The model in **Equation 1** was estimated twice (i.e.; with and without the firm-specific variable FIRM) using the cross sectional, time series data over 1976-84. The results of estimating both models along with t-statistics are shown in **Table 2**. For the purpose of simplicity and comparison, the variable FIRM is replaced by its corresponding airline code in **Table 2**. Note that the Durbin-Watson value in **Table 2** indicates that the hypothesis that there exists no first order serial correlation cannot be rejected. No correction was, therefore, preformed on the results obtained.

Analysis

The coefficient ß in both model estimations is positive and statistically significant at the 0.05 level. The hypothesis that there exists a positive and strong association between profitability and hub dominance cannot, therefore, be rejected. The value of coefficient ß in the second model estimation indicates that a one percent increase in an airline's hub dominance index will likely be associated with an increase of 0.178 percentage points in its profitability index.

The results suggest that a dominant airline at a particular hub reaps the monopoly profits by charging higher fares.

The inclusion of the firm-specific variable increased the regression fit as the value of the multiple correlation coefficient (R^2) improved from 0.326 to 0.543. The yearly dummy variables suggest increasing losses between 1980 and 1982, with 1984 marking a period of financial recovery for the industry. This pattern seems to accord with the trends in fuel prices as well as the intense competition among airlines in the first few years of deregulation which may have led to destructive airfare competition.

Table 2:
Results of Model Estimating Equation 1

VARIABLE/ COEFFICIENT	MODEL 1 Estimated Value	MODEL 1 T-Statistics	MODEL 2 Estimated Value	MODEL 2 T-Statistics
CONSTANT	-1.535	-0.60	-11.239	-3.23
DOM	0.205	4.74	0.178	2.58
Y78	-3.041	-1.04	-2.865	-1.06
Y80	-6.529	-2.28	-7.631	-2.79
Y82	-10.964	-3.86	-11.324	-2.70
Y84	-6.953	-2.36	-6.899	-2.39
Y86	-6.713	-2.22	-8.247	-2.86
AA			12.658	3.02
AL			11.882	2.34
BN			10.468	2.03
CO			14.351	3.43
DL			14.422	3.35
EA			12.435	2.85
FL			10.662	2.66
NW			12.888	2.91
OZ			13.662	3.04
PI			9.361	1.61
RC			18.112	3.99
TW			7.089	1.65
UA			10.593	2.76
WA			10.123	2.33
	R-Squared =	0.33	R-Squared =	0.54
	Durbin-Watson =	2.18	Durbin-Watson =	2.41

The above results coupled with those obtained by Toh and Higgins suggest that increased emphasis on hubbing cannot, by itself, contribute to airline profitability unless it is associated with airline dominance of the main hub (or the few hubs) it uses for its operations. To elaborate further, we provide two examples. The first is the case of USAir which, in 1980, established a hub in Pittsburgh where competition was generally absent. While most airlines experienced losses in 1980 and 1982, USAir posted impressive profits, and, overall, USAir was the most profitable airline between 1980 and 1984. The second example is Pride Air which, in late 1985, adopted a complete hub-and-spoke system with New Orleans as the main hub (i.e., hubbing index equals 0.5). Pride Air could not withstand competition at New

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Orleans from other dominant airlines (such as Delta, Eastern, Continental, Southwest, etc.) and had to declare bankruptcy by the end of 1986.

In light of the above, one can conclude that the commonly held belief that hubbing leads to more successful operations is attributed mainly to the fact that most airlines tend to dominate the main connecting hubs within their systems. This is apparent by examining individual airline's ranking at the major hub as shown in **Table 1.**

HUB DOMINANCE AND AIRLINE ENPLANEMENT SHARE

The second phase of this study is to assess the impact of hub dominance on airline enplanement share at the hub airport. Route monopoly and market dominance have been the subject of many studies which attempted to relate an airline's passenger share in a given market to its frequency share of the total flights in the market. Renald (1970), Fruhan (1972), and Miller (1979) showed that the relationship between an airline's market share and its frequency share follows an S-curve; meaning that high frequency shares are associated with even higher market shares and conversely. Following the same approach, we will test the hypothesis that there exists a positive and strong relationship between an airline's enplanement share at a given airport and its hub dominance. An airline's enplanement share at a hub is estimated as the ratio between the airline's passenger enplanements to the total passenger enplanements by all airlines at that hub.

The Model

In developing an enplanement share model for an airline at a given hub, it will be assumed that passengers exhibit utility maximization behavior in their choice of a carrier. It can be readily shown that by maximizing the passenger's utility function, the standard multinomial logit probabilistic choice model can be obtained, such that:

Equation 2

$$P_{im}=\frac{e^{U(im)}}{\sum_{j} e^{U(jm)}} \qquad (2)$$

where P_{im} is the probability that a passenger at hub m will select an airline i, or simply the passenger enplanements share of airline i at hub m; and U(im) is the utility of airline i to passengers at hub m. The logit model has widely been used in similar applications, primarily because of its advantages relative to other probabilistic choice model forms. For a discussion and derivation of the logit model, the reader can refer to Kanafani (1985, Ch. 5).

The passenger utility's function consists of a vector (i.e.; array) of the carrier's service attributes at a particular hub. These attributes include flight frequency, aircraft size, airfare, departure schedule, and airline image. For the purpose of this study, the utility function will consist of the carrier's flight frequency at the hub. Other variables influencing an airline's share of passenger enplanements will be accounted for by incorporating a firm-specific variable in the utility function. Based upon the above discussion, the utility function U(jm) is given as:

Equation 3

$$U(jm)=\alpha\, LOG(FREQ)_{jm}+\beta_{j} FIRM_{j}+\epsilon \qquad (3)$$

where $FREQ_{jm}$ is the flight frequency of airline j at hub m, $FIRM_j$ is a firm-specific variable which takes on the value one for carrier j and zero otherwise. α and β are the coefficients to be estimated, and ϵ is the error term. *A PRIORI* sign of α is expected to be positive since an increase in flight frequency will yield better levels of service. Levels of service include such measures as frequency of flights, aircraft size, on-time performance, in-cabin service, and flight itinerary (e.g.; non-stop flights versus multi-stop or connecting flights). Note that the flight frequency variable (FREQ) is expressed in a logarithmic form in order to examine, in

Table 3
Input Data for the Enplanement Share Model for 1980

Hub	Airline	Enplanements (millions)	Aircraft Departures
ORD	AA	3745.3	47344
	DL	1975.2	25286
	UA	6217.5	77356
PIT	AL	3022.6	54291
	TW	978.2	15068
	UA	619.5	9651
DFW	BN	3645.7	57352
	AA	3079.5	45658
	DL	1677.5	23257
ATL	DL	10342.7	119472
	EA	7620.1	105170
	RC	789.1	21620
DEN	FL	2230.6	41880
	CO	2107.1	31711
	UA	2670.3	39002
MSP	NW	1787.1	25618
	RC	1023.3	24060
	WA	532.2	8481
MIA	PA	1078.4	14030
	EA	2289.9	27881
	DL	819.7	12116
STL	TW	2333.1	34127
	OZ	1042.4	24705
	AA	661.9	14637
LAX	WA	1953.7	23380
	AA	1673.3	17337
	UA	3033.6	34989

Source: "Airport Activity Statistics of Certificated Route Air Carriers." U.S. Department of Transportation, The Federal Aviation Administration, 1980

relative terms, the relationship between an airline's enplanements share and its flight frequency share as explained earlier. In his investigation of passenger choice of an airport in a multiple airport region, Harvey (1986) showed that using a nonlinear specification for yielded a better estimate than a linear one.

In order to test the hypothesisthat there exists a positive and strong relationship between airline enplanement share and its hub dominance, the logit model in **Equation 2** is estimated. In their survey of airline strategies to dominate their main hubs, Ghobrial and Sousa (1987)showed that most passenger enplanements at a given hub are carried by the top three airlines. The logit model was, therefore, estimated using data for the top three airlines a given hub. The hubs selected for estimating the model are those listed in **Table 1** over the period from 1976 to 1984. For the purpose of illustration, **Table 3** shows the 1980 data for aircraft departures and passenger enplanements for the top three airlines dominating particular hubs.

Using the cross sectional, time-series data for the selected airlines over 1976-84, passenger enplanements for each airline at a given hub were converted to proportions and the logit model in **Equation 2** was estimated twice (i.e.; with and without the firm-specific variable FIRM). Because of the logarithmic specification of the model, two observations were omitted from the data, that is, Piedmont's operations at ROA in 1976 and 1978. The results of estimating both models along with t-statistics are shown in **Table 4**. For the purpose of comparison, the variable FIRM is replaced by its corresponding airline code in **Table 4**.

Table 4:
Results of Estimating Equation 3

VARIABLE/ COEFFICIENT	MODEL 1		MODEL 2	
	Estimated Value	T-Statistics	Estimated Value	T-Statistics
FREQ	1.0505	57.79	1.0790	63.45
AA			0.0928	1.27
AL			-0.3360	-3.33
BN			0.0022	-0.03
CO			0.0799	0.82
DL			0.0453	0.60
EA			-0.1899	-2.88
FL			-0.1928	-1.86
NW			0.0482	0.53
OZ			-0.1812	-1.88
PA			0.2029	2.06
PI			-0.2063	-2.22
RC			0.5561	-6.87
TW			0.1459	1.73
UA			0.1010	1.41
WA			0.1313	0.17
LOG LIKELIHOOD				
At Zero Slope:		-263.62		-262.62
At Convergance:		-44.74		13.59
R-Squared:		0.94		0.97

Analysis

The sign of α agrees with its *A PRIORI* sign and the FREQ variable seems to be highly significant. Moreover, using the statistical hypothesis testing, one cannot reject the hypothesis that the coefficient α is greater than one in both model specifications. The relationship between enplanement share and hub dominance seems, therefore, to follow an S-curve meaning that high frequency shares at a given airport are associated with even higher enplanement shares, and conversely.

For the purpose of illustration, we consider the case of Delta Airlines' operations at Atlanta Hartsfield Airport between 1976 and 1986. **Figure 1** depicts the trends in Delta's share of the total aircraft departures at Atlanta (i.e., hub dominance index) along with its share of passenger enplanements (in percentage points). The observed pattern Delta's dominance of Atlanta through frequency concentration is evident. Because Delta is the dominant airline at Atlanta its share of passenger enplanements is consistently higher than its corresponding aircraft departure share as depicted in **Figure 1**.

The disproportionality phenomenon between an airline's enplanement share and its frequency share is attributed to passenger identification with the dominant carrier in the region. For instance, local travelers originating in the Atlanta area learn which carrier offers the greatest flight frequency (Delta in this case) and given the existence of information costs, passengers tend to contact that carrier first. Information costs include the time and communication expenses of calling several airlines and/or travel agencies. Passengers flying Delta via Atlanta can enhance their chances of enjoying single-plane service. Furthermore, through increased frequency concentration at Atlanta and a proper timing of flight arrivals and departures, Delta Airlines can offer connecting passengers a single-airline service (i.e., on-line connection,) thus reducing the passengers chances of missing a connection or losing baggage.

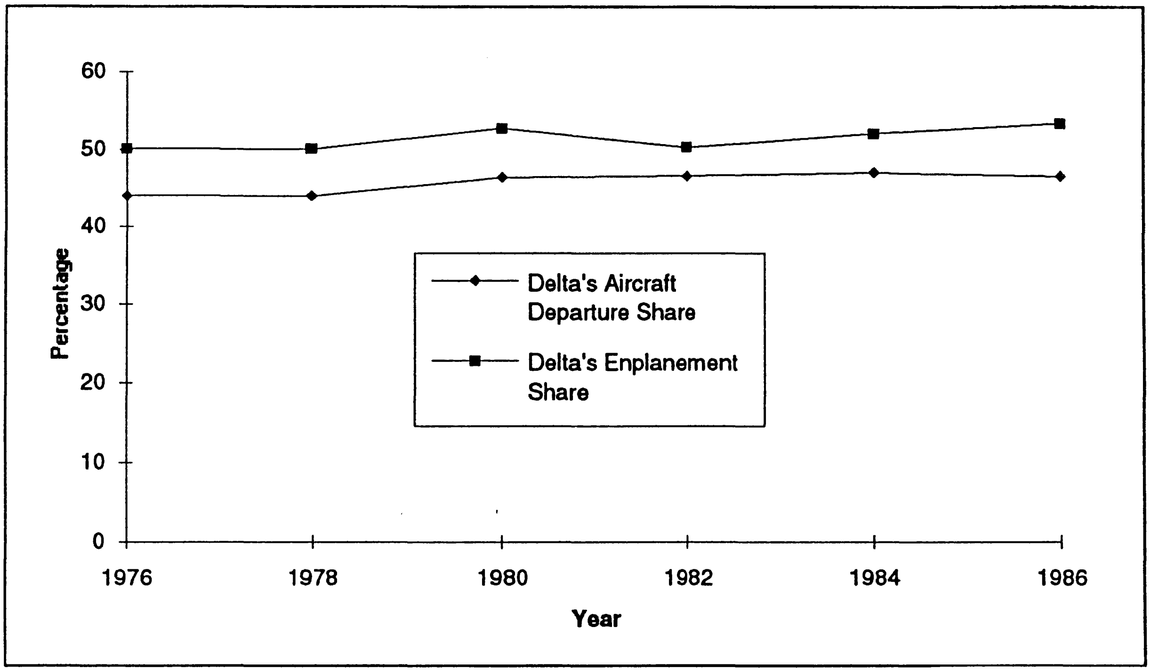

Figure 1: Aircraft Departure Share and Enplanement Share for Delta Airlines at Atlanta Hartsfield Airport

CONCLUSIONS

This paper attempts to shed light on the phenomenon of airline frequency competition as a means to dominate its major connecting hubs. It is concluded that airline network centralization (hubbing) cannot by itself contribute to airline profitability unless it is associated with airline dominance of the main hub (or the few hubs) it uses for its operations. By dominating its

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main hubs, airlines can reap the monopoly profits from the markets served by these hubs and realize higher enplanement shares than departure shares.

Several conclusions emerge from the above discussion. First, in establishing a hub, airlines seem to follow a number of strategies including: 1) staying away from competition by monopolizing the hub such as USAir operations at Pittsburgh, and Piedmont at Charlotte; and 2) engaging in frequency competition to dominate the hub, and establishing regional identification with passengers to promote airline services. Examples are Delta at Atlanta, American at Dallas/Fort Worth, and TWA at St. Louis. Second, to take advantage of the nonlinear relationship between passenger enplanements share and frequency share, airlines may elect to operate higher flight frequency with relatively smaller size planes. Agarwal and Tally (1985) showed that passengers are more sensitive to changes in frequency delay (i.e., changes in flight frequency) than to changes in stochastic delay (i.e., changes in aircraft size). Pacific Southwest Airlines appeared to have adopted this strategy by replacing many of its B-727 with the smaller Bae 146-100 and Bae 146-200 aircraft in many routes in the California corridor. Third, since there has been a trend in mergers between two airlines dominating the same hub. Examples are Northwest and Republic at Minneapolis, TWA and Ozark at St. Louis, and Southwest and Transtar at Houston. One can view these mergers as a means to create a monopoly power and charge higher airfares. From the perspective of policy making, the issue of monopoly power ought to be considered when approving mergers between airlines hubbing at the same airport.

Finally, while hub dominance through frequency competition offers opportunities both for airlines and passengers, it may pose problems as well. Excessive frequency concentration at airports may result in some negative economic impacts such as congestion, pollution, and noise. Congestion delay may outweigh some of the benefits of aircraft concentration by increasing flying costs for airlines and travel time for passengers.

LIMITATIONS OF THE STUDY

In attempting to assess the impact of hub dominance on airline profitability and enplanement share, it was assumed that flight frequency is the only explanatory variable in the econometric models. Other variables contributing to airline profitability and enplanement share were accounted for by incorporating a firm-specific variable in the models. While the results showed a positive strong relationship between profitability and enplanement share on one hand and hub dominance on the other, further research is needed to incorporate other hub dominance strategies in the models. These include airfare structure at the main hubs, aircraft size, arrangements for traffic feeding through a subsidiary, and frequency concentration during peak periods.

Atef Ghobrial holds a Ph.D. in Transportation, a Master of Business Administration, and a Master of Science in Civil Engineering from the University of California at Berkeley. He is presently an Associate Professor at Georgia State University where he directs the aviation administration program. He has published several papers in the area of air transportation, and is a transportation consultant in the U.S. and abroad.

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