VARIGLOG DOMESTIC FREIGHT ROUTE STRUCTURE - IMPACTS DUE TO VARIG RESIZING

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Abstract

VARIGLOG domestic freight route structure is heavily dependent on VARIG domestic passenger route structure. Commercial and operational agreements allow the sharing of the large cargo compartments of VARIG wide-bodies passenger planes, therefore freight VARIGLOG routes were structured accordingly. This reality changed dramatically in 2005 and 2006 with VARIG bankruptcy process and selling hustle and its immediate resizing and restructuring. The paper analyzes the impacts of VARIG resizing and restructuring over VARIGLOG aiming to identify the more promising all cargo routes VARIGLOG should seek presence. VARIGLOG presence was modeled with a Binomial LOGIT model calibrated using 2001 to 2004 available data. The model uses explanatory variables that represent: (1) domestic routes cargo demand, (2) regional economic activity, (3) routes length, (4) rivals supply, (5) passenger flights cargo supply and (6) a dummy of airline hub airport. Application of the model showed improved fitting compared to an early model developed by Silveira et al (2006). Finally, the model was used to evaluate VARIGLOG all cargo route structure policy in a changing market where VARIG has reduced its passenger domestic flights in the second period of 2006. Results showed about 30 routes with increased indication of good opportunities for VARIGLOG presence in this new scenario.

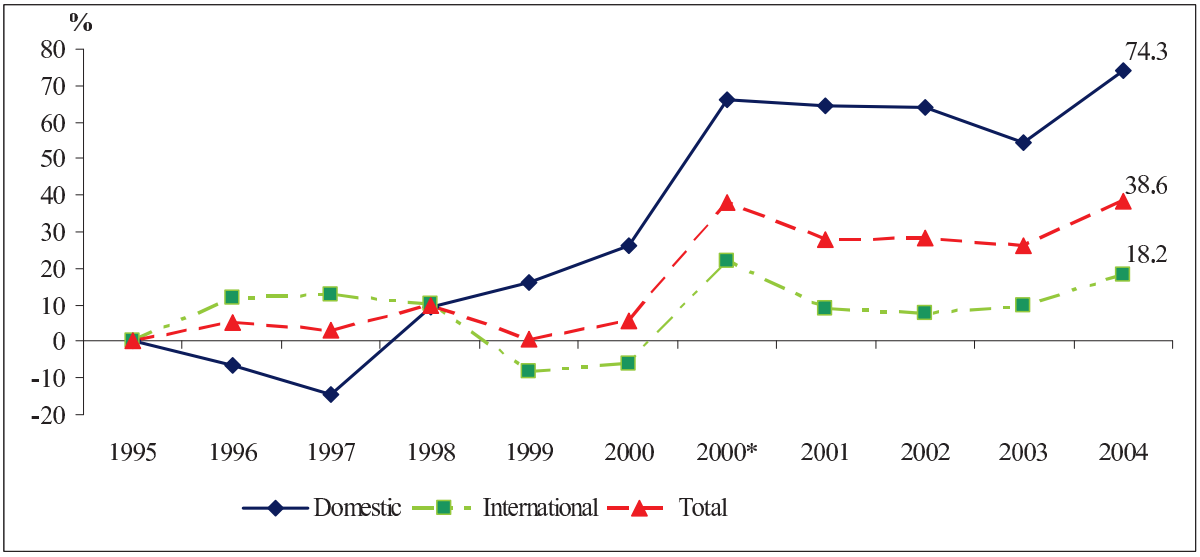
Keywords: route choice, choice models, LOGIT model, air freight, cargo airline.

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1. INTRODUCTION

Airlines are managing flights network and logistics services to support the increasing demand for door-to-door freight transportation, sometimes multimodal services, integrating air and road. However, according to Novaes (2004), Brazil does not have yet a national express delivery company servicing the whole country like FEDEX, UPS or DHL. VARIGLOG, the major Brazilian air freight carrier and the sixth logistic forwarder with greatest revenues (TIGERLOG 2006) in the country in 2003, using full cargo aircraft and VARIG's (its former owner) wide bodies, needs to have a specific flight network to act as a important player in this market.

Air cargo handling and storage alone in 2004 represented 27.4% of INFRAERO (federal company that owns and manages the 67 major airports in Brazil) total revenues, with an increase of 17.7% when compared to last year, while passenger taxes revenues represented 17.9% of total earnings of INFRAERO Annual Report (2004). Figure 1 shows air freight (ton.km) flow growth evolution in Brazilian airline industry from 1995 to 2004, according to DAC (2004).



Source: DAC, 2004

Figure 1: Air Freight Flow Growth Evolution (%) in Brazil from 1995 to 2004

The main purposes of this paper are:

1. Identify the decision pattern for VARIGLOG presence in air freight transportation market with all cargo aircraft, from years 2001 to 2004.

2. Evaluate the impact of VARIG resizing and domestic route structure changing over VARIGLOG, identifying the more promising all cargo routes to seek presence.

This paper will initially describe VARIGLOG domestic route structure. We then estimate a Binomial LOGIT model to recognize the airline pattern of presence in all cargo routes, improving a previous model developed by Silveira *et al* (2006). Finally, results are applied to the actual changing scenario to assist the airline to face the reduced cargo compartment supply reorganizing its all cargo route network.

2. VARIGLOG ROUTE STRUCTURE

VARIGLOG began independent operations in August 25, 2000, following VARIG Cargo Section closure, aiming to offer integrated logistic freight transportation beyond what was offered by VARIG. In 2004, VARIGLOG grew 23% over 2003 figures (Perez and Oliver, 2005) and flew approximately 250 thousands tons of cargo, 20.9% of that in the Brazilian domestic market. It is the largest logistic Brazilian operator in the road-air sector, reaching 4,500 Brazilian cities and more than 200 countries with the help of its strategic alliance with road freight carriers.

VARIGLOG operations up to 2006 relied heavily in the use of available belly space in VARIG aircraft [76% of all freight transported by VARIGLOG used this means in 2004, according to DAC (2004)] besides its own full cargo aircraft. Table 1 and 2 show VARIGLOG information regarding available fleet mix and cargo capacity in 2004. This data shows that large air passenger aircraft can take more cargo than medium sized all cargo aircraft. Low capacity aircraft (Cessna 208) operated by third parties are used from São Paulo/Guarulhos (GRU), in São Paulo, and Belém (BEL) airports, in courier service at high density short routes not served by VARIG passenger flights.

Table 1: Passenger Aircraft Freight Capacity (VARIG fleet)

AIRCRAFT	Number in Fleet	Cargo Capacity (ton)	Cargo Capacity (m3)
B737-300/400	36	2 - 2.5	10
B737-500	13	1.5	8
B737-700	2	2.5	10
B737-800	2	3.6	19
B767-300	7	18.9	54
B777-200	6	20	86
MD-11	15	26.5	86

Source: www.dac.gov.br

Table 2: All Cargo Aircraft Freight Capacity (VARIGLOG fleet)

AIRCRAFT	Cargo Capacity (ton)	Cargo Capacity (m^3)
B727-100	16	96
B727-200	23	112
DC-10/30	72	453
C208		3.2

Source: www.dac.gov.br

Therefore, VARIGLOG managed its flight network so that its all cargo aircraft are mainly assigned to high cargo density routes or to routes where VARIG belly supply are not adequate due to aircraft capacity constraint, limited flight schedule, or cargo nature.

2.1. Domestic Route Structure

VARIGLOG domestic freight route structure was up to VARIG bankruptcy process and subsequent selling attempts heavily dependent on VARIG domestic passenger route structure. This reality changed dramatically in 2005 and 2006 with VARIG selling hustle that culminated with VARIGLOG acquisition of VARIG and its immediate resizing that is still in progress.

According to the initial expectation of this research, VARIGLOG focus its freight flights network for postal service agreements and for dense and medium-haul routes aiming to achieve high levels of utilization of its aircraft capacity for each route, as described by company managers interviewed by the authors.

High and medium cargo capacity aircraft (DC 10-30 and B-727, respectively) are used to connect the main airports, while medium and low capacity aircraft (B-727 and Cessna 208, respectively) and/or trucks are used in less dense routes, in a multimodal arrangement.

São Paulo/Guarulhos (GRU) and Brasília (BSB) airports were the main VARIGLOG hubs for all cargo flights from 2001 to 2004. Guarulhos (GRU), main freight airport in Brazil, ensured connections with VARIG's passenger flights. Postal Service flights, in a total of 4 routes, have been distributed from Brasilia (BSB). Guarulhos–Manaus (GRU–MAO), the top demand in the domestic all freight route in the country, is a direct route because of its unique characteristics. A large fleet of trucks in complement to the air route network are used in the freight distribution from the main hubs, mainly for short distances, where air transportation is less competitive.

Figure 2 describes VARIGLOG's route network:



Figure 2: VARIGLOG Domestic Route Network (All Cargo Aircraft)

2.2. Domestic Freight Airlines

Five airlines reported regular domestic all cargo flights in 2004 in Brazil. Table 3 identifies these airlines and their fleet.

Table 3: Airlines with Regular Domestic All Cargo Flights in 2004

AIRLINE	Fleet
ABSA	1 DC-08, 1 B-767
SKYMASTER	3 DC-08-6, 5 B-707
TOTAL	3 B-727-200
VASP	2 B-727-200, 2 B-737-200
VARIGLOG	4 B-727-100, 4 B-727-200, 3 DC-10-30

Source: www.dac.gov.br

Non-regular all cargo airlines BETA, TCB and TAF also did some cargo flights in 2004, mainly night flights for the Postal Service and non-regular cargo flights on route Manaus–Guarulhos (MAO–GRU).

3. CHOICE MODELLING

Analytical choice models are used in transportation as a stochastic approach to predict share of alternatives, such destination choice, mode choice and route choice. Logit model is the one most used in transportation analyses literature. Previously work modeled the patterns of airlines entry in new markets, considering entering as an indication of expected profitability based on individual markets and firms characteristics. If decision of entry is made by the firms at the same time a problem of simultaneity emerges.

Literature may be divided in two different approaches. One set of papers have estimated the likelihood of entry as a function of firm and market characteristics, typically using Probit models. Bogulaski, Ito e Lee (2004) and Oliveira (2005), analyzes the probability of entry in Low Cost Carriers market, respectively in the case of Southwest Airlines and Gol Airlines, which is the first LCC in the South America. Bogulaski, Ito e Lee (2004) estimates the probability of entry in markets with no presence of Southwest in the year 1990 aiming to measure the impact of this airline into standard air carriers. Oliveira (2005) models the entry of Gol in the Brazilian market to recognize and compare it to traditional LCC`s patterns of entry. Sinclair (1995) evaluates the importance of hub and spoke flights structures for entry and exit decision in airline market.

Another set of paper estimates structured models of entry decisions. Reiss and Spiller (1989) estimate entry in small airline markets in each at most one airline provides direct service. They set up a structural model of cost and demand conditions and assume a particular form of competitive behavior to estimate the probability of an airline offering direct flights as a function of market and endpoint characteristics. Berry (1992) further develops the approach of estimating the

equilibrium number of firms in the market. He models the simultaneous decision of an airline to provide service in the market to recognize the number of firms offering direct service in a given market as a function of route and endpoint characteristics and the carrier's presence at the endpoints airports. He assumes that after controlling for airport presence, airlines in the sample are identical up to an identically and independently distributed error term in a profit equation that represents unobserved firm heterogeneity.

Literature regarding entry choice in air freight transportation market is rare. Ohashi et al. (2005) estimates a Logit model to analyze de decision of destinations (airports) for transshipment in Northeast Asia. They recognize which attributes are most important for freight forwarders to chose an airport and evaluate the share of Seoul airport as a new logistics hub if investments were made in infra-structure to reduce time of transshipment.

In this paper we developed a Binomial LOGIT choice model to describe VARIGLOG choice for presence (entry) or absence at domestic cargo routes, in accordance with data gathered in 2004. Equation (1) is the final formulation to be applied to sample data:

$$\text{Prob}\,(PRES_{kt} = 1) = 1 / [(1 + \text{EXP}\,[-\alpha + \Sigma_n\, \beta_n . X_{nkt} + \varepsilon_{kt})] \quad (1)$$

where:

Prob ($PRES_{kt}$ = 1) = indicate probability of presence [1] or absence [0] of VARIGLOG in a given route k ($1 \leq k \leq n$) and instant t.

α and β_n = modeling coefficients to be estimated.

X_{nkt} = explanatory variable n for route k at time t.

ε_{kt} = unobserved error term, i.i.d., with zero mean.

The proposed Binomial LOGIT model will consider the dependent binary variable as route presence (1) or absence (0), in accordance with VARIGLOG participation or not in each air cargo route in 2004. Explanatory variables will be selected considering the relevance of the cargo density of the route, the regional economic activity, the air route length, rival's supply, passenger flights cargo supply, along with the route Postal Service and courier service demand.

3.1. Route Sample and Variables Definition

Regular domestic air cargo statistics for years 2003 and 2004 were collected from DAC Annual Air Transportation Report (DAC, 2003; 2004) and ranked in order of route importance (total cargo and Postal Service tons flew). 220 routes with the highest freight

demand were selected to be further investigated with respect to VARIGLOG presence or not from 2001 to 2004. It was noticed that VARIGLOG was present with all cargo aircraft in 31 (14.1%) of this routes, using eleven aircraft, and as expected concentrated in the routes with the highest cargo demand. The sample, as compared to Oliveira (2005) and Boguslaski, Ito and Lee (2004) data, is suggested to be representative and well suited to the modeling proposed. Oliveira (2005) has selected a sample of 896 non directional city pairs for 117 (13.1%) presences of GOL, with 22 aircraft, while Boguslaski, Ito and Lee (2004) have used data of 2,500 non directional city pairs for 201 (8%) presences of Southwest.

As proposed by Evans and Kessides (1993), the concept of routes as being one directional connection between any origin and destination was employed in this paper. This approach takes into account the effect of non balanced cargo demand as observed in the 2004 data. We used the airport instead of the city as the origin or destination in building the routes. This procedure allowed identifying multiple airport regions for the routes associated with cargo. Airports that imposed restrictions to the operations of cargo aircraft (CGH – São Paulo, Congonhas and SDU – Rio de Janeiro, Santos Dumont) and private airports were discarded from the sample.

The sample was made of data from domestic regular flights only (operated by five companies), considered more representative than the ones flew by non-regular companies (three companies). Data regarding the regular flights are structured and reliable, and account for the cargo service of interest in this study, which is the service readily available to meet domestic cargo demand.

Previous papers devoted to the estimation of route entry decision have selected explanatory variables representing attributes of demand, distance, population income, rivals presence, market share of firms and some dummy variables to capture specificities in the market. Boguslaski, Ito and Lee (2004) assume that selecting exogenous variables for each year could cause undesirable endogeneity to emerge, even if market characteristics and airline entry decision pattern have changed during the period.

In this study we considered six possible explanatory variables: total cargo demand on the route, Postal Service demand on the route, route air length, average economic activity level at route origin and destination, non VARIGLOG available cargo supply on the route, VARIG available cargo supply of passenger flights on the route and a variable to

account for VARIGLOG hub at GRU when this airport is an endpoint of a given route. A description of each variable considered in the modeling is presented below:

- **$PRES_{kt}$**: dependent binary variable indicating VARIGLOG presence [1] or absence [0] on each domestic route k, with full cargo aircraft, in period t, from 2001 to 2004, as informed by the airline. Presence was considered for every route with direct flight and also for every route with intermediate landings if there was no cargo transference between planes. Intermediate landings in cargo flights were assumed not to compromise the level of service and were therefore accepted. Not considering transshipment in the hubs as presence seems to be reasonable because freight transshipments between all cargo and VARIG's flights in Guarulhos (GRU) are difficult to measure. Additionally, transshipments in Brasilia between VARIGLOG´s postal service flights are only possible for routes Guarulhos (GRU) / Cuiabá (CGB) / Porto Velho (PVH) and Salvador (SSA) / Belém (BEL), both with low levels of demand. Bogulaski, Ito and Lee (2004) considered presence only for direct flights without stops, but their study concerned LCC and passenger demand. We assumed presence in accordance with Evans and Kessides (1993) 1% minimum level of operation (MLO). Routes where VARIGLOG accounted for more than 1% of the total domestic air cargo flown annually were assigned with presence [1]. Domestic legs of international cargo flights were not considered when flying only with international cargo.
- ***dem_{kt}***: air cargo demand data (in units of 1,000 kg) in each one of the 220 domestic cargo routes k, sampled on time t = 2004;
- ***mp_{kt}***: domestic Postal Service demand (in units of 1,000 kg) in each one of the 220 domestic cargo routes k, sampled on time t = 2004;
- ***$dist_k$***: route length (km) from origin to destination (great circle distance obtained from DAC) for each route k;
- ***$pibMED_{kt}$***: variable responsible for the measurement of the level of economic activity (PIB, same as GDP) at route k origin and destination (in units of R$ 10,000,000), obtained from IBGE (2006) for year t = 2004. This variable was constructed as the sum of the PIB at the airport counties of origin and destination. For Guarulhos (GRU) airport the PIB amounts to the sum of the PIB of the cities of São Paulo and Guarulhos;
- ***oft_{jkt}***: regular supply of non VARIGLOG (j) air cargo capacity (in units of 10,000 m^3) on each sampled route k, on time t, 2004. It was used the same MLO level (1%) used to define variable $PRES_{kt}$. Supply was

measured in terms of volume to avoid evaluation problems associated with aircraft performance and climate considerations. Data on capacity was gathered from DAC (www.dac.gov.br) available monthly HOTRAN (Regular Airline Flight Schedule). Aircraft cargo capacity was obtained from *Airplane Characteristics for Airport Planning* manuals (BOEING 1969, 1988, 1989) for each type of aircraft. Regular flights from ABSA, SKYMASTER, TOTAL and VASP were considered. Non regular flights were not considered. This variable disregard cargo compartment's supply of other domestic airlines because only one of them, TAM Airlines, offered in 2004 wide bodies flights (Airbus 330), and only at Guarulhos–Recife–Guarulhos (GRU–REC–GRU) market.

- ***oftP***$_{vkt}$***:*** cargo supply capacity at VARIG (v) passenger flights (m^3) in each considered route, k, on time t, 2004 as obtained from DAC monthly HOTRAN. Cargo capacity excludes aircraft passenger baggage capacity.

We do not have data to represent and measure some attributes such as air freight type, airport infra-structure, forwarders agreements, air company reputation, fleet capacity restriction, air postal service agreements, unsatisfied demand due to lack of service, flight transshipments, passenger flight frequency, non regular supply, etc. These attributes may be important to presence determination pattern but were not considered in this study. Hence they compose the error term of estimated econometric model.

One variable, representing VARIGLOG's hub at Guarulhos International Airport (GRU), is tested as an attempt to minimize the effects of non observed attributes related to this airport:

- ***gruk***: dummy variable that accounts for Guarulhos (GRU), taking value one [1] if this airport is one point of an origin-destination pair of a given route, k, or zero [0] otherwise.

According to initial expectation, VARIGLOG's presence is concentrated at dense routes seeking to maximize cargo compartment utilization. As long as this paper investigates presence with all cargo aircraft even if VARIGLOG is present in the market with passenger aircraft, it seems to be reasonable to consider that all cargo presence does not impact expressively on passenger demand.

3.2. Variables Statistics

Statistics in Table 4 show that VARIGLOG's choice of presence behaves according to the initial expectation of this paper. Routes with presence ($PRES_{kt}$ = 1) have high air freight and postal service demand levels (average of 7,009.68 ton/year and 2,019.29 ton/year) and

are concentrated in medium-haul services (mean of 1,563.9 km). As long as VARIGLOG seeks to maximize utilization of VARIG's passenger flights with its own all cargo flights network, variable $oftP_{vkt}$ shows statistics in accordance to the initial expectation, although presence is observed in routes with high cargo compartments supply, which is explained by the fact that VARIGLOG presence is focused on those routes with such high levels of demand that cargo compartment supply is too low or insufficient for market size.

Table 4: Variables Designation and Statistics.

Variable	Designation	Mean (N = 220)			Std. Error
		$PRES_{kt}=1$	$PRES_{kt}=0$	Full Sample	Full Sample
$PRES_{kt}$	freight aircraft presence (0;1)	-	-	0.14	0.35
dem_{kt}	air freight demand (1,000 kg)	7,009.68	1,318.17	2,120.159	3,549.56
mp_{kt}	air postal demand (1,000 kg)	2,019.29	183.85	442.48	1,250.25
$dist_k$	distance (km)	1,563.9	1,062.67	1,133.29	751.47
$oftP_{vkt}$	cargo compartment supply (m^3)	30,577.58	5,343.68	8,899.36	28,925.75
oft_{jkt}	rivals supply (10,000 m^3)	3.96	1.01	1.42	3.06
$pibMED_{kt}$	economic activity (R$10,000,000)	5,532.98	2,656.98	3,062.23	2,832.36
gru_k	hub of Guarulhos (GRU) airport (0;1)	0.55	0.15	0.20	0.40

4. MODEL ESTIMATION

Table 5 shows the coefficient estimations associated with the model with best fit to the data with variables dem_{kt}, mp_{kt}, $dist_k$, $oftP_{vkt}$ and $dem_{kt} * oftP_{vkt}$. The other variables tested are not present in this best model. Model (1) in Table 5 was previously developed by Silveira *et al* (2006), with a sample of 330 observations, Model (2) is the best model developed in this paper.

4.1. Estimation Results

Results of application of model (2) in the data sample indicates probability of presence (greater than ½) for 21 routes out of 31 with actual presence of VARIGLOG and probability of absence (less than ½) for 187 routes out of 189 with actual absence. Therefore model (2) was successful in predicting 67.74% of presences and 98.94% of absences, with accuracy of 94.55%, improving model (1) early developed by Silveira *et al* (2006) for a sample of 330 routes. Models estimated by Bosguslaski, Ito and Lee (2004) and by Oliveira (2005) predicted 81.8% and 65.5% of presences, respectively in the case of Southwest and GOL.

Negative coefficient of Variable $oftP_{vkt}$ represents VARIGLOG pattern of maximization of VARIG passenger aircraft cargo compartment utilization before deciding

to be present with all cargo aircraft. Variable $dem_{kt} * oftP_{vkt}$ was tested and its positive coefficient indicates that negative influence of cargo compartment supply in the dependent variable $PRES_{kt}$ is minimized if high levels of demand is observed justifying all cargo aircraft presence. Variable $pibMED_{kt}$ was expected to be positively correlated with dependent variable indicating economic activity and potential to buster freight demand. However an unexpected negative signal was observed causing this variable to be excluded from Model (2). Variable oft_{jkt}, failed probably because it does not capture non regular rival's supply, difficult to be measured. Total of observations correctly predicted (94.55%) indicates reasonable results for a stochastic model.

Table 5: Estimated Coefficients (standard errors and z-statistics in parentheses).

significant at 10%, † significant at 5%, ‡ significant at 1%.

VARIABLES	(1)	(2)
constant	-5.981517 ‡	-5.913964 ‡
	(0.8538183/-7.01)	(1.062515/-5.57)
dem_{kt}	0.0012152 ‡	0.001038 ‡
	(0.0002664/4,56)	(0.0003678/2.82)
mp_{kt}	0.0007001 †	0.001049 ‡
	(0.0002878/2,43)	(0.0003607/2.91)
$dist_{k}$	0.0013941 ‡	0.0017742 ‡
	(0.0003832/3,64)	(0.0004621/3.84)
$oftP_{vkt}$	-0.0001785 ‡	-0.000514 ‡
	(0.0000562/-3.17)	(0.0001665/-3.09)
$dem_{kt} * oftP_{vkt}$		0.00000005 †
		(0.00000002/2.41)
LR chi2	86.94	100.2
Log likelihood	-52.93	-39.35
% presences predicted	51.61	67.74
% correctlly predicted	99.33	94.55
# predicted=1 / # actual=1	16/31	21 /31
# predicted=0 / # actual=0	297/299	187/189
Mc Fadden *Pseudo* - R2	0.4852	0.56
McKelvey e Zavoina *Pseudo* - R2	0.838	0.985
Lave e Efron *Pseudo* - R2	0.491	0.585
N. observations	330	220

5. SIMULATION EXERCISE - 2006 SCENARIO

We apply model (2) with data of VARIG's cargo compartment supply on September 2006, just after its selling, and expand these results for a period of one year to evaluate routes with changing presence probability due to the new scenario after VARIG dramatic reduction of cargo compartment supply. Data for $oftP_{vkt}$ was extracted from 2006 HOTRAN and most recent data was also used for the other variables: dem_{kt}, mp_{kt} and $dist_k$.

5.1. Results and Recommendations

Results for the scenario show 31 routes with VARIGLOG absence in 2004 and indication of presence (probability greater than ½) after VARIG supply reduction (Table 6). The first 15 routes have high indication of presence with probability greater than 0.9, confirming that VARIGLOG is strongly dependent on VARIG's supply and showing additional potential risks to VARIGLOG freight transportation services without an all cargo flights network reevaluation.

Table 6: Ranking of Routes with Indication of Presence.

	ROUTES		$PRES_{kt}$ (0 - 1)
	Orig.	Dest.	
1	BSB	MAO	
2	MAO	BSB	
3	GRU	CNF	
4	CNF	GRU	
5	GIG	BSB	
6	GRU	CWB	
7	GIG	SSA	
8	GIG	MAO	> 0.9
9	BSB	GIG	
10	MAO	GIG	
11	SSA	GIG	
12	POA	GIG	
13	GIG	REC	
14	REC	GIG	
15	GIG	POA	
16	FOR	GIG	
17	FOR	BSB	
18	BEL	GRU	
19	NAT	GIG	
20	GIG	FOR	> 0.7
21	REC	FOR	
22	POA	FOR	
23	REC	SSA	
24	REC	BSB	
25	BSB	FOR	
26	FOR	SSA	
27	FOR	REC	
28	GRU	NAT	> 0.5
29	IGU	GRU	
30	GIG	BEL	
31	NAT	GRU	

Airports (IATA code)
BEL: Belém Intl. Airpt. - Val de Cans
BSB: Brasília Intl. Airpt. - Pres. Juscelino Kubitschek
CGB: Cuiabá Intl. Airpt. - Mal. Rondon
CGH: São Paulo Intl. Airpt. - Congonhas
CNF: Confins Intl. Airpt. - Tancredo Neves
CZS: Cruzeiro do Sul Intl. Airpt.
CWB: Curitiba Intl. Airpt. - Afonso Pena
FOR: Fortaleza Intl. Airpt. - Pinto Martins
GIG: Rio de Janeiro Intl. Airpt. - Tom Jobim
GRU: Guarulhos Intl. Airpt. - Gov. Franco Montoro
IGU: Foz de Iguaçu Intl. Airpt. - Cataratas
MAO: Manaus Intl. Airpt. - Eduardo Gomes
NAT: Natal Intl. Airpt. - Augusto Severo
POA: Porto Alegre Intl. Airpt. - Salgado Filho
PVH: Poto Velho Intl. Airpt. - J. Teixeira de Oliveira
REC: Recife Intl. Airpt. - Guararapes, Gilberto Freire
SDU: Rio de Janeiro Airpt. - Santos D`umont
SSA: Salvador Intl. Airpt. - Dep. L. E. Margalhães

The 10 first routes in Table 6 have the highest presence probability, with estimated results of more than 0.99. Therefore, the following routes (with origin and destination at the same airport and respective ranking position) are highly recommended to be considered by VARIGLOG:

- BSB–MAO (1) and MAO–BSB (2);
- GRU–CNF (3) and CNF–GRU (4);
- GIG–BSB (5) and BSB–GIG (9);
- GIG–SSA (7) and SSA–GIG (11);
- GIG–MAO (8) and MAO–GIG (10);
- POA–GIG (12) and GIG–POA (15).

Additionally, one way only route Guarulhos–Curitiba (GRU–CWB), sixth on ranking at Table 6, could be connected with an intermediate stop of a southbound route, such as Rio de Janeiro, Galeão–Porto Alegre (GIG–POA). Needless to say that additional factors must be considered in this presence determination. VARIG supply reduction may be temporary and could be progressively reestablished. Geographic issues, continuity of route network and possible flight transshipments should also be considered before defining a route structure. Moreover, fleet capacity restriction could limit presence increase in a short term basis. According to simple exercise, for instance, in order to be present at the 24 routes with highest probability indication in Table 6, VARIGLOG will need to incorporate at least 4 aircraft to its fleet, when assuming an average of six legs per aircraft per day and not considering maintenance contingency. Another strategy could be to modify flight schedules to achieve higher aircraft utilization levels.

6. SUMMARY AND CONCLUSIONS

This paper proposes a choice model to investigate a domestic all cargo aircraft route network decision of a Brazilian airline. Results indications confirms initial expectation that VARIGLOG focus its freight flights network at dense and medium-haul routes aiming to achieve high levels of utilization of its aircraft's capacity for each route.

The model developed was successful in predicting 21 out of 31 effective presences and 187 out of 189 absences of VARIGLOG,

with 94.55% correct predictions. Although variable gru_k was not representative and unobserved attributes remain incorporated to the error term, ε_{kt}, the model showed improved fitting compared to an early model developed by Silveira *et al* (2006).

Finally, the model was used to evaluate VARIGLOG all cargo route structure policy in a changing market were VARIG has reduced its passenger domestic flights in the second period of 2006. This exercise shows 31 routes with VARIGLOG absence in 2004 and indication of presence after VARIG supply reduction. 15 routes have high indication of presence with probability greater than 0.9, confirming that the airline is strongly dependent on VARIG's supply and showing additional potential risks to VARIGLOG freight transportation services. Therefore this paper provides a tool to assist VARIGLOG to reevaluate its route network structure. Additional subjective factors such as previous experience, manager sensibility, firm limitations, stock holders concerns, etc, must be considered during this decision process.

REFERENCES

BERRY, S. (1992). Estimation of a model of entry in the airline industry", *Econometrica*, vol. 60, p. 889-917.

BOEING (1969). *Airplane characteristics for airport planning – B 727*. Seattle: Boeing Commercial Airplane Division, 1969.

_____. (1988). *Airplane characteristics for airport planning – B 737*. Seattle: Boeing Commercial Airplane Division, 1988.

_____. (1989). *Airplane characteristics for airport planning – B 767-200-300*. Seattle: Boeing Commercial Airplane Division, 1989.

BOGUSLASKI, R., ITO, H. and LEE, D. (2004). Entry patterns in the Southwest Airlines Route system. *Review of Industrial Organization,* vol. 25, p. 317-350.

DAC. Departamento de Aviação Civil. (2004). *Anuário do transporte aéreo*. Rio de Janeiro, 2004.

DAC. Departamento de Aviação Civil. (2003). *Anuário do transporte aéreo*. Rio de Janeiro, 2003.

EVANS, W. and KESSIDES, I. (1993). Localized market power in the U.S. airline industry. *Review of Economics and Statistics*, vol. 75, p. 66-75.

IBGE. Instituto Brasileiro de Geografia e Estatística (2006). *Produto interno bruto dos municípios brasileiros 2004*. Rio de Janeiro, 2006. Disponível em: http://www.ibge.gov.br

INFRAERO. Empresa Brasileira de Infra-Estrutura Aeroportuária (2004). *Boletim de Informações Gerenciais*. Brasília, 2004.

NOVAES, AG. (2004). Logística e gerenciamento da cadeia de distribuição: estratégia, operação e avaliação. Rio de Janeiro: Elsevier, 2004.

OHASHI, O., KIM, TS., and YU, C. (2005). Choice of air cargo transshipment airport: an application to air cargo traffic to/from northeast Asia July 2004. *Journal of Air Transport Management*, vol. 11, p. 149-59.

OLIVEIRA, AVM. (2005). An empirical model of low cost carrier entry: the entry patterns of

GOL Airlines. *Working Paper N. 002* – Center for Studies of Airline Competition and

Regulation (NECTAR) Working Paper Series. São José dos Campos, SP. Disponível em: www.ita.br/~nectar.

PEREZ, L. and OLIVER, S. (2005). As cargueiras voam muito bem, obrigado. *Avião Reveu,* vol. 73, p. 76-77. Motor Press, Brasil.

REISS, PC. and SPILLER, PT. (1989). Competition and entry in small airline markets. *Research in Transportation Economics*, vol. 4, p. 33-47.

SILVEIRA, L., MULLER, C. and CORREIA, A. (2006). An empirical model for domestic freight route choice – the case of VARIGLOG Airlines. In Proceedings of the Air Transportation Research Society Conference, Nagoya, 2006.

SINCLAIR, RA. (1995). An empirical model of entry and exit in airline markets. *Review of Industrial Organization*, vol. 10, p. 541-557.

TIGERLOG. Training and Consulting (2006). *Data collected on the website*. Available from: http://www.TIGERLOG.com.br on Sept. 20th, 2006.