CIRJE-F-291

Choice of Air Cargo Transshipment Airport:
An Application to Air Cargo Traffic to/from Northeast Asia

Hiroshi Ohashi
The University of Tokyo

Tae-Seung Kim
Korea Transport Institute

Tae Hoon Oum
Chunyan Yu
University of British Columbia

July 2004

Choice of Air Cargo Transshipment Airport: an application to air cargo traffic to/from Northeast Asia

July 2004

Hiroshi Ohashi
University of Tokyo
Faculty of Economics
ohashi@e.u-tokyo.ac.jp

Tae-Seung Kim
Korea Transport Institute
todang@koti.re.kr

Tae Hoon Oum
Chunyan Yu
Sauder School of Business
University of British Columbia
tae.oum@sauder.ubc.ca
chunyan.yu@sauder.ubc.ca

Abstract

Based on a unique data set of 760 air cargo transshipment routings to/from the Northeast Asian region in 2000, this paper applies an aggregate form of multinomial logit model to identify the critical factors influencing air cargo transshipment route choice decisions. The analysis focuses on the trade-off between monetary cost and time cost while considering other variables relevant for choice of transshipment airport. The estimation method considers the presence of unobserved attributes, and corrects for resulting endogeneity via a two-stage least squares estimation using instrumental variables. Our empirical results show that choice of air cargo transshipment hub is more sensitive to time cost than the monetary costs such as landing fees and line-haul price. For example, our simulation results suggest that a one-hour reduction in total transport and processing time for a particular O-D air cargo traffic would be more effective than a US$1,000 reduction in airport charges. This suggests that it is important to reduce air cargo connecting time at an airport via adequate investment in capacity and automation even by increasing landing and other airport charges.

Acknowledgements:

The authors would like to thank the Northeast Asian Economic Forum and Korea Transport Institute for project funding for data collection. Tae Oum acknowledges gratefully the Social Science and Humanities Research Council (SSHRC) of Canada for research grant support.

Choice of Air Cargo Transshipment Location: an application to air cargo traffic to/from Northeast Asia

1. Introduction

World air cargo is a US$46 billion annual business (Hoang, 2002), and is expected to more than triple by 2021 (Boeing, 2002). Asian countries have experienced strong growth in the international air cargo business after the recovery of the financial crisis in 1997, and are expected to lead all other international geographic markets in average annual air growth over the next 20 years.

Northeast Asia (NEA), including China, Korea and Japan, is the major growth markets as well as being the largest of Asian markets. It is home to three of the top five air cargo airports in the world: Hong Kong ranked 2nd in 2003 with 2.7 million tones of air cargo; Narita ranked 3rd at 2.2 million tonnes; and Incheon ranked 5th with 1.8 million tonnes. Shanghai Pudong and Beijing Capital International Airport were also ranked among the top 30 cargo airports in the world in 2003. The governments in the NEA countries have been actively pursuing economic policies that would help develop designated regions in their respective countries into global or regional transport and logistics hub. The ability of the airports in these designated regions to attractive carriers and air cargo traffic, particularly with respect to transshipment traffic, is crucial to the establishment of a transport and logistics hub.

Many factors affect an airport's ability to attract transshipment cargo traffic, including the airport's current traffic flow patterns; airport infrastructure capacity and activities; linkage with regional and intercontinental airport network; service quality; and airport cost factors. While several existing studies provide conceptual discussions on the effects of these factors (Caves, 1996; Oum and Park, 2004), a severe lack of empirical studies on this topic remains. The purpose of this paper is to offer some empirical evidence on how airport service quality and transport cost factors affect the choice of air cargo transshipment location with an application to the NEA region. The paper applies an aggregate form of multinomial logit model to identify critical determinants of transshipment cargo flows. The analysis incorporates two major factors, monetary cost (such as line-haul cost and airport charges) and service quality in terms of time cost including cruising/flight time and connecting time at transshipment airports, along with some other controls. Our model estimation considers the presence of unobserved attributes, and corrects for the resulting endogeneity using appropriate instrumental variables. Our results indicate that the choice of transshipment location is more sensitive to service quality (in terms of time cost) than to monetary cost: cargo carriers/shippers would be willing to pay more than $1,000 in the form of increased airport charges to achieve a one-hour reduction in the transport and processing time for a particular O-D air cargo traffic. This finding implies that it would be more effective for the airports to attract transshipment cargo by reducing air cargo connecting time, rather than reducing airport charges.

A series of simulation exercises are also conducted using the estimated model to further measure the effect of changes in airport charges and service quality attributes on the transshipment location choices. Two policy alternatives are examined, one calls for reduction in airport charges, and the other calls for reduction in cargo connecting time at the transshipment airport. The results from the simulation exercises indicate that a 20% increase in transshipment traffic could be achieved by a 30% reduction in air cargo connecting time or a 50% reduction in airport charges. This finding implies that it may make sense to raise airport charges for capacity expansion and automation including electronic data interchange (EDI) system in order to improve air cargo connecting time at the airport.

The paper is organized as follows: Section 2 provides a general discussion of air cargo business, and introduces the data set and important explanatory variables. Section 3 describes the market share model for a particular O-D air cargo traffic which is used to uncover determinants of air cargo transshipment location choice in the NEA region. Section 4 presents estimation results. Section 5 conducts simulation exercises using the case of Seoul/Incheon. Section 6 summarizes our main findings and conclusions.

2. Air Cargo Business and Data

This section describes the international air cargo business in the NEA region, and introduces major variables that likely influence the air cargo transshipment activities. Many of the discussions on institutional features of air cargo business are taken from Rigas Doganis (2002).

The logistics of moving air cargo is more complicated than that of moving passengers. It involves packaging, preparing documentation, arranging insurance, collecting cargo from shippers, facilitating customs clearance at origin and destination, and completing final delivery. This complexity of the job has encouraged the growth of specialist firms that carry out these tasks on behalf of shippers and provide an interface between shippers and airlines. In this paper, we consider freight forwarders, consolidators, or large shippers as decision makers with respects to air cargo routing choice. For simplicity, we refer these three agents altogether as “freight forwarders,” unless the use of this term creates confusion.

Air cargo business is inherently competitive. This is because most cargo, except for emergency cargo, is indifferent to the routings from its origin to its destination. A shipper is not concerned whether a shipment goes from New York to Kuala Lumpur via Tokyo, Shanghai, or Hong Kong as a transshipment point, provided that the shipment arrives at Kuala Lumpur within the expected time. Thus, in most cases, a freight forwarder would choose among numerous routings and carriers to move their cargo to the final destination. Therefore, there is more competition among airports for transshipment cargo than for passengers.

Transshipment is a very important aspect of the air cargo industry in the NEA region as indicated by Figure 1. Figure 1 shows that 70 % of air cargo traffic between North American and the NEA countries has one or more transshipment points before reaching their final destination in 2000. Anchorage has the highest share of transshipment air cargo originating from North America, as most U.S. carriers use short or medium haul aircrafts to collect their cargo and consolidate them at Anchorage, and then use long-haul aircrafts to deliver to the NEA region. About half of the air cargo traffic going from NEA to North America is transshipped at Tokyo. A similar pattern could be observed in the NEA-Europe markets as shown by Figure 2: about 60 % of the cargo traffic between the NEA region and Europe has at least one transshipment point on the way to the destination; and Tokyo is a dominant transshipment point in the market.

Ideally, we would like to trace each shipment from their origin to destination. However, we have to rely on air cargo traffic flow between gateway airports because of lack of data. Thus, we implicitly assume that there is no alternative routing choice beyond the gateway airports. Table 1 lists major gateway airports and their main characteristics related to the air cargo traffic in the NEA region. The airports are listed in descending order of landing fees for Boeing 747-400 with a gross takeoff weight of 395 tones. A casual observation on the landing fees indicates that the U.S. airports tend to have lower landing fees than the Asian airports. Japanese airports have the highest landing charges: Narita airport charges US$9,700, roughly 19 times higher than Atlanta that has the lowest charges in our sample.

The number of runways ranges from 1 at Kansai to 6 at Chicago O'Hare, and all the airports in our sample are able to accommodate Boeing 747-400 as indicated by the length of runways[1]. Anchorage has the largest cargo handling capacity, whereas Beijing has the smallest cargo handling capacity, though significant capacity expansion is expected over the next two decades. Singapore has by far the largest cargo terminal space. The variables in the last two columns, throughput and average hours for loading/unloading and customs clearance, are described later in this section.

Assuming direct flights are not available[2], freight forwarders choose transshipment points to minimize their total shipping cost. Two categories of cost factors are generally considered: monetary cost and time cost. Monetary cost includes both airport charges and cargo line-haul cost. Time cost includes cruising/flight time (which is highly correlated with route distance), loading and unloading time at airports, and customs clearance and other processing time, and waiting time for the next available flight.

The following provides a description of how each of the cost factors is defined and measured.

[1] B747-400 requires runways with a minimum length of 2,800 meters.
[2] Shippers would obviously prefer direct route when other conditions are the same. We focus on routes with at least one transshipment in this study.

2.1. Monetary Costs

There are two main components of the monetary costs: (A) line-haul cost and (B) airport charges.

A. Line-haul Cost:

Line-haul cost reflects essentially aircraft operation cost and depend on the distance of the route/flight. The actual rates shippers/ freight forwarders pay to airlines are often confidential, and to certain extent, reflect the shippers/freight forwarders' bargaining power. Therefore, we use the route specific line-haul rates published by IATA (International Air Transport Association, 2001). It should be noted that these rates are most likely higher than the actual rates paid by the shippers/freight forwarders.

The distribution of the line-haul cost in our data set is presented in Figure 3. There is a clear trend that line-haul cost increase with distance, whereas unit line haul rate (per KM) decreases with distance. Notice that short-haul routes are within the Asia region, the medium-haul routes are mostly those to and from North America, and the longest are routes to and from Europe.

B. Airport Charges:

Airports charges generally include landing (and/or takeoff) fees, aircraft parking and hangars charges, security charges and noise related charges and cargo handling charges. To simplify the estimation, we use the term "landing fee" to reflect the total airport charges. These airport charges are generally related to the weight of the aircraft, and in most cases, airlines pay the same rates[3]. Freight forwarders have to pay a share of the landing fee based on the weight of their air cargo.

Table 1 lists the typical charges a Boeing 747-400 would pay at the various airports in our sample. The level of airport charge reflects the costs of operating and maintaining the airports, but is also affected by the level of government grant and subsidies. As a result, airport charges vary enormously across different airports, ranging from US$9,700 at Narita (Tokyo) to US$512 at Anchorage. Because of the limited data availability of airport charges, the B747-400 landing fee is used as a representative airport charge.

2.2. Time Costs

The three most important elements of the time costs are: (A) cruising/flight time, (B) loading/unloading and customs clearance time, and (C) waiting time caused by schedule delay.

---

[3] Some airports do distinguish between international and domestic carriers with respects to charge rates, or signatory versus non-signatory carriers (in the U.S.).

A. Cruising Time

Cruising time refers to the travel time between two airports. It is generally determined by route distance (and the type of aircraft), which in turn is closely correlated with the line-haul cost as show in Figure 3.

B. Loading and Unloading (L/UL) Time, and Customs Clearance Time

Cargo loading and unloading time, and customs clearance time are considered as indicators of service quality at an airport. Freight forwarders have to take these time costs into account when choosing a transshipment point. They are likely to try to avoid a route which requires a long customs clearance time at the transshipment airport. The last column in Table 1 lists the average time a shipment needs for loading and unloading and customs clearance time at our sample airports. It appears that there is little variation among the airports with respects to the total airport handling time.

C. Schedule Delay

The time a shipment spent at a transshipment airport not only depends on the loading/unloading and customs clearance time, but also depends on the frequency of connecting flights. More flights mean shorter waiting time for the shipment to get on a connecting flight. This waiting time for connecting flights is referred to as schedule delay. Following Douglas and Miller (1974), we use the inverse of the frequency as an indicator of expected schedule delay. The expected schedule delays are different across different routes (city pairs). We calculate the expected maximum schedule delay by taking a sum of schedule delays on arrival and departure. Freight forwarders would shy away from an airport with long expected schedule delay, holding the other attributes of the airports constant.

The schedule delay indicates how many hours on average a shipment has to wait at an airport before catching the next flight. During the waiting period, the shipment has to clear the customs and be reloaded. If the customs clearance and reloading takes so long that the shipment has to stay more than the minimum expected schedule delay time, missing the closest connecting flight, the shipment has to be held at the airport until the next available flight. The expected total time at a particular airport *j* will be referred to as connecting time and can be calculated as follows:

$$\text{Connecting time}_{ij} = (n_{ij}+1)*(\text{expected schedule delay})_{ij}$$
$$\text{s.t: } (n_{ij}+1)*(\text{expected schedule delay})_{ij} > (\text{L/UL time + custom clearance time})_j > n_{ij}*(\text{expected schedule delay})_{ij}$$

where Connecting time $_{ij}$ is the time that a shipment has to stay at airport *j* on route *i*; n_{ij} is the number of scheduled flights that have to be missed for route *i* at airport *j* in order for a shipment to go through the customs clearance and reloading process.

2.3. Throughputs

Throughput is the total traffic volume at an airport. This is an important determinant in explaining the transshipment location choice in two ways. First, traffic volume increases with the market size in an airport's catchment area, and thereby more flights to meet the demand. Secondly, the throughput size can be used as a proxy for the size of hinterland demand, thus serves as a good indicator of the attractiveness of the adjacent city or region as a global or regional transport and logistics hub, which is supported by the literature on economic geography (Fujita, Krugman, and Venables, 2000) finds the agglomeration effects of multi-national corporations (MNC) location choice. Table 1 lists the throughput by airport in the year of 2000. A large portion of the cargo traffic at Hong Kong and Anchorage are transshipment cargo, whereas the high traffic volume in Tokyo is due in large part to the size of its origin-destination demand.

2.4. Some Observations

We select five airports as the main competing transshipment points for the air cargo traffic in the NEA region: Beijing, Osaka, Shanghai, Seoul, and Tokyo.[4]

Figure 4 is a scattered diagram indicating the relationship between transshipment shares and landing fees (in US$) for the selected airports. The transshipment share for a particular airport is calculated as the average of transshipment shares of all origin-destination pairs passing through the airport. That is, our transshipment measure is based on the sub-population of the O-D cargo volume, and thus, does not take include direct shipments.

Figure 4 indicates that, with the exception of Tokyo, there is a negative correlation between landing fee and transshipment share. Tokyo has a high share with high landing fee, making it distinctively different from other airports.

Figure 5 shows the relationship between transshipment share and cargo connecting time. The figure reveals, with the exception of Tokyo again, a positive relationship between the share and connecting time. One might think that this relationship appears odd because longer connecting time appears to increase the transshipment share of the airport. This relationship, however, should not be interpreted as the causal effect of time. Rather Figure 5 indicates that connecting time, or service frequency, may be endogenous: the increase in share would exacerbate congestion, forcing connecting time longer. In the estimation, we carefully control for this endogeneity by employing a 2-stage least squares (2SLS) method using appropriate instrumental variables.

[4] Although we included Bangkok as a transshipment point in our econometric work, we do not pay as much attention on Bangkok in our analysis because it is mostly the air cargo hub between the north and south Asian regions, but does not compete as vigorously as other airports for attracting inter-continental transshipment air cargo. Hong Kong is excluded from our analysis because data on the air cargo flow to/from mainland China via Hong Kong is incomplete.

Both Figures 4 and 5 find that Tokyo's Narita airport is very different from other airports: Tokyo has a high transshipment share yet with highest landing fee and shortest connecting time. Historical reasons place Tokyo as an outlier in the data set (see Hansen and Kanafani, 1990). Tokyo was the main Asian destination for air cargo with the United States in the late 1950s when Japan was enjoying high economic growth. Tokyo's dominance in the trans-pacific market continued to grow with Japan's strong local market and the liberal fifth freedom rights of U.S. airlines out of Tokyo. The last two decades have, however, witnessed that Tokyo's dominance is slowly changing, but still Tokyo enjoys its first-comer advantage from the past. In order to deal with this unique situation for Tokyo, a dummy variable is used to recognize Tokyo's special characteristics in our econometric work.

2.5. Unobserved Variables

In addition to the monetary and time cost factors discussed above, many other factors may also influence freight forwarders' choice of transshipment points. Unfortunately, we do not have data to represent and measure these factors. The absence of these factors in the model estimation may bias estimation results if not properly corrected. Three such factors, congestion, the international aviation regulation, and technology advance in customs administration, are discussed in the following:

(1) Airport Congestion

Airport congestion likely correlates with schedule delay. As the number of flights increases, airports gradually become congested, given the limited capacity of the airport infrastructure and facilities. This congestion factor, since unobservable, would likely remains in the error term obtained from estimation. We therefore need to correct for the potential correlation between the error (which reflects in part the level of congestion) and the explanatory variable, schedule delay.

(2) Bilateral Air Services Agreements and Inter-airline agreements

International air transport is regulated by a complex web of bilateral air services agreements signed between countries. Although liberal bilaterals have become more widespread, many bilaterals still impose capacity restriction and other restrictions (See Cheung, et. al, 2002, for a recent case in China). Such restrictions are not reflected by our explanatory variables. Other features of state involvement in aviation are also not directly observable.

Bilateral air services agreements and inter-airline agreements influence flight frequencies. In countries where more than one national carrier operates international services, the country's own licensing or regulatory controls may influence the sectors on which their airlines operate. We do not have an appropriate measure of this state involvement in aviation, thus will not be able to identify the effects of the regulation directly.

(3) Advance in Customs Administration

Historically, revenue raising was a major function of customs administration. Importance of this role diminishes as tariff barriers are gradually being removed. Customs administration increasingly plays an important role in attracting international air cargo. Unpredictable delay in customs clearance procedure, or unexplained changes in the classification of goods disrupt efficient logistic flows, and thus hinder the hub development in air cargo transshipment. New technology, such as EDI system, simplifies the customs procedure by computerizing shipment information, and makes it more efficient by allowing pre-clearance of the shipment. Some airports, such as Singapore, have established bonded areas so that the transshipment goods can avoid customs. Though customs clearance in many airports is still processed manually, other airports strive to simplify the processes. Unfortunately, we do not observe the extent of efficiency enhancement achieved at the airports in customs clearance process. Since the efficiency of customs is often measured by time, a concern might arise on the correlation between the unobserved customs efficiency and the time cost variable. Similarly, if the airlines realize that freight forwarders has a higher willingness to pay for the airports that have efficient customs administration, and there are routes in which such airlines have some degree of market power, they might increase the line-haul cost to increase their revenue. This generates another concern for the endogeneity with the line-haul cost variable.

3. Model Estimation

The route choice process by freight forwarders (or shippers) can be described by a random utility discrete choice model. Since we do not observe the route choice of individual freight forwarders, we aggregate individual forwarders to obtain a behavioral model of transshipment, while still allowing for heterogeneity across the forwarders. Similar techniques have been applied to identify factors that affect the route choice decisions in ocean shipping and general freight transport. For example, Malchow and Kanafani (2004) use a modified discrete choice model to identify the factors that influence a carrier's selection of a port for shipment. Fernandez, de Cea, and Soto (2003) use a random utility choice model to model the shippers' decisions in their multi-modal supply-demand equilibrium model.

Each freight forwarder, *i*, is assumed to maximize the following indirect utility function by choosing the route, *j*, among a set of alternative transshipping routes in a particular origin-destination gateway pair:

$$u_{ij} = \sum_k X_{jk}\beta_k + \xi_j + \varepsilon_{ij},$$

where u_{ij} is the freight forwarder *i*'s utility from choosing the route *j* to ship cargo from the origin to the destination. The utility can be interpreted as the negative of the transshipping cost. The vector, X_j, includes the variables that reflect the freight forwarder's transshipment location choice. A k-th component of this vector is denoted by J_{oke}. The previous section points out that the monetary and time costs are the two most important determinant factors in the freight forwarders' route choice decision[5]. Thus, the explanatory variables include connecting time that indicates how many hours a typical air cargo shipment has to stay at a particular airport. The explanatory variables also include two monetary costs variables: line-haul cost and landing fees as discussed in Sections 2.1 and 2.2. We also include as explanatory variables airport throughput as a hinterland demand indicator, and the Tokyo dummy interacting with line-haul cost, landing fee, and time cost variables. As discussed in Section 2.5, the explanatory variables do not cover all the important factors affecting the transshipping location choices made by freight forwarders. We therefore include an error term, ξ_j, to capture such unobserved factors with zero mean, and another error term, ε_{ij}, to reflect the slope of the transshipping route demand curve. We impose the assumption on ε_{ij} that generates a standard logit structure. In order to obtain consistent estimates of the parameters, β, our estimation method need to take into account of the possible endogeneity problem, i.e., the correlation between some explanatory variables and ξ_j. The method for correcting the endogeneity bias in will be discussed in Section 3.2.

3.1. The Logit Model

In our analysis, a freight forwarder (or shipper) chooses a transshipment point to maximize its utility (or minimizes its shipping cost). The standard multinomial logit model can be used to form a closed form market share model. The share for route *j* with in a particular combination of the origin and destination ports is given by:

$$s_j = \frac{\exp\left(\sum_k X_{jk}\beta_k + \xi_j\right)}{\sum_{p\in\Phi_{O-D}} \exp\left(\sum_k X_{pk}\beta_k + \xi_p\right)}.$$

The share of the route *j* is denoted by s_j, and $\Phi_{\text{O-D}}$ is all the transshipping routes in a given pair of the origin and destination airports. A log-transformation yields an aggregate linear regression model for the route *j* (Berry, 1994):

$$\ln(s_j) = \sum_k X_{jk}\beta_k + \xi_j - \log\left(\sum_{p\in\Phi_{O-D}} \exp\left(\sum_k X_{pk}\beta_k + \xi_j\right)\right),$$

[5] Cullinane and Toy (2000) identified 15 categories of attributes that may affect the freight route/mode choice decisions.

where $j \in \Phi_{O\text{-}D}$. Since the term inside the log-transformation is highly nonlinear, we look at the within estimates by subtracting two share equations of the routes *j* and *l* within the same O-D pair. This procedure removes a common component affecting the routes within the same O-D pair, and, in particular, the third term in the right hand side of the above equation:

$$\ln(s_j) - \ln(s_l) = \sum_k [X_{jk} - X_{lk}]\beta_k + (\xi_j - \xi_l), \qquad (1)$$

Equation (1) is our base estimation model. Notice that the constant term is cancelled out in (1). The identification comes from the variations in transshipment characteristics in each combination of airport pairs. We could use the ordinary least squared method (OLS) to estimate this model, however, we are concerned about the possible correlation between some explanatory variables (i.e., $X_{jk} - X_{lk}$) and the unobserved error (i.e., $\xi_{jk} - \xi_{lk}$). The next section explains the sources of this endogeneity, and the method to correct the problem.

3.2. Identification

There are concerns for endogeneity in that some explanatory variables in (X_{jk}-X_{lk}) may be correlated with the difference in the unobserved attributes,(ξ_{jk}-ξ_{lk}). One source of the possible endogeneity comes from the unobservable variables discussed in Section 2.5. In particular, we are concerned about the possible bias from three missing variables: congestion, aviation regulation, and customs efficiency. All three variables are likely to correlate with service frequency, which is used to create a schedule delay, a main component of the time cost variable, connecting time. Furthermore, unobserved customs efficiency might also correlate with line-haul cost in the presence of airline market power: some airlines may be able to charge a high cargo rate over a route with efficient customs procedure, because the route would attract forwarders who want to save on shipping time. The correlation of the unobserved attributes with the explanatory variables would generate a biased estimate without the use of appropriate instruments.

In the model estimation, we use instruments that would correlate with the endogenous variables, but not with the unobserved attributes. Two sets of instruments are considered. The first set of instruments is related to airport characteristics: length of the runways, and cargo terminal areas. We expect that these instruments would control for endogeneity of time costs. The length of runways indicates what type of aircrafts can land on the airport. Sufficient runway length is required for a B747 to land and take off, and thereby this instrument may correlate with the frequency of particular aircraft types, and therefore time cost. The cargo terminal area may correlate with loading/unloading time, though the direction (sign) of the correlation is ambiguous. If the terminal areas are large relative to the size of airport throughput volume, there may be economies of scale which makes loading/unloading process shorter, leading to a negative correlation between these two variables. If there are diseconomies of scale, a positive correlation would be expected. Those two variables may likely be exogenous to congestion, aviation regulation, and customs efficiency. Thus they can serve as instruments in our estimation.

The second instrument regarding line-haul cost is route distance. As discussed in Section 3.1, line-haul cost is highly correlated with route distance. In particular, Figure 3 indicates a strong relationship between distance and line haul cost: the longer the distance, the faster the unit line-haul rate (per km) drops (by a declining rate). In order to capture this nonlinear relationship between the line haul rate and distance, we include the distance variable up to the second order polynomials in the set of instruments.

In a model with exogenous airport characteristics, the characteristics of other competing airports can also be used as instruments. The transshipment volume at an airport depends also on the relative attractiveness of other airports. Holding the characteristics of a particular airport constant, the airport would lose share of transshipment cargo as the characteristics of other airports improve. The characteristics of other airports are thus related to service frequency, but since characteristics are assumed to be exogenous, they are valid instruments.

4. Estimation Results

As discussed in the previous section, line-haul cost and connecting time are likely endogenous, thus a two-stage least square method (hereafter 2SLS) is used in our model estimation. The model is estimated using a data set of 760 air cargo transshipment routings to/from the Northeast Asian region in 2000.

Table 2 reports the 2SLS estimation results of two alternative specifications[6]: Model (A) uses the line-haul cost as the cost variable while Model (B) uses distance as a proxy for the line-haul cost variable. The difference between the two specifications (A) and (B) lies in how the potential endogeneity of line-haul cost is treated. Specification (A) treats line-haul cost as an endogenous variable, and Specification (B) uses a proxy variable, distance, to substitute the line-haul cost variable. Since the physical distance between airports is exogenous, specification (B) does not require instruments for the line-haul cost. Note that we still need to control for endogeneity of connecting time.

Tokyo's Narita has been a dominant transshipment airport in the NEA region since the 1950s with strong hinterland demand. In order to control for this historical element discussed in Section 2.4, we include a Tokyo dummy for the variables of landing fee, connecting time, and line-haul cost (for Model (A)), or distance (for Model (B)). Tokyo-

---

[6] The F-statistics for 2SLS equations indicate that the instruments are not weak. The statistics for over-identifying restrictions (the J-statistics) test the validity of instruments conditional on there being a set of valid instruments that just identify the model. The statistics shown in Table 2 would not reject the hypothesis, with the 99-percent confidence level, that some of the instruments are orthogonal to the unobserved error term.

specific instruments are used to control for interaction between endogenous variables and Tokyo dummy variable. The positive coefficients for the Tokyo dummies provide some support for the existence of special "Tokyo effects". However, none of these Tokyo related variables are statistically significant in either Model (A) or in Model (B). This is probably because Tokyo is only one of many transshipment airports in the data set.

The results from Models (A) and (B) are generally consistent, and can be summarized as the following:

- Connecting time is the most important factor the decision makers consider in choosing air cargo transshipment location and routing;
- Landing fee is the second most important factor although it is not statistically significant factor in Model (A);
- There is some marginal evidence that freight forwarders (shippers) may try to avoid large and congested airport as indicated by the negative coefficient of the 'throughput' variable; and
- Line-haul cost or distance is the least significant factor of the four variables included in our analysis in influencing transshipment location choice.

Overall, the regression results show that time saving (and by implication, service quality improvement) is far more important for influencing the air cargo routing and choice of transshipment airport than the monetary costs such as aircraft landing fees and/or line-haul cost. The results from Model (A) indicate that a one-hour reduction in connecting time could off-set the effects of a US$1,361 increase in airport charges. This result is consistent with the fact that airport user charges account for just over 5 percent of airlines total costs on average for the world's airlines as a whole. The result is also consistent with the fact that the air cargo business generally deals with high value, time sensitive goods with a high value-to-weight ratio. Since cargo rates are generally based on weight, the higher the value of an item in relation to its weight, the smaller will be the transport cost as a proportion of its final market price. This tendency for high-value goods to switch to air transport is reinforced if they are also fragile and liable to damage or loss if subject to excessive handling. Our estimation results capture this nature of the time-sensitive air cargo business.

5. Simulation Exercises

The previous section examines the factors that determine freight forwarders' choice of transshipment location through the estimation of a closed form market share model. The estimation results reveal that connecting time plays a rather important role in the route choice by freight forwarders.

Based on the estimation results in Table 2, this section examines how effective certain policy alternatives would be in increasing transshipment volumes at an airport. In particular, we look at the case of Korea, as Korea recently declared their intention to become a regional logistic hub in the NEA region. To become a regional logistics hub, its hub airport must be able to attract air carriers and transfer/connecting traffic. We focus on two policy alternatives that could help attract more transshipment cargo to Korea's hub airport (Seoul/Incheon): reduction of airport charges and reduction of connecting time through shortening loading and unloading time, simplification of customs clearance procedure, and increasing flight service frequency.

As the goodness of fit statistics, R-squares and the First-Stage F-statistics, indicate that Model (A) is far superior to Model (B). The estimates from the specification (A) are used in a series of simulation exercise to examine potential outcome from implementing different policy measures.[7] The simulation results are presented in Figures 6 and 7.

Figure 6 shows how the transshipment volume would change with the reduction of airport charges at Seoul/Incheon airport. The simulation examines two scenarios: a 10% and a 30% reduction in airport charges. The results show that a 30% reduction in airport charges in Seoul/Incheon would increase its transshipment traffic by 11.7%, most of which would come from Kansai airport in Osaka. This modest impact is due, in part, to the fact that airport charges at Seoul/Incheon are already rather low comparing to those at other airports in the region. The diversion of traffic from Kansai to Seoul/Incheon is not surprising in view of the geographical proximity between the two airports, and these two airports have very similar catchment area for trans-shipment air cargos.[8]

Two counterfactual policy scenarios with respect to connecting time are examined in Figure 7: a 10% (14 minutes) and 30% (40 minutes) reduction in connecting time from the existing level. As expected from the estimation results in Table 2, the impacts of this policy would be significant: the transshipment traffic at Seoul/Incheon would increase by 18.3% if the connecting time should be shortened by 40 minutes.[9]

The simulation results indicate that reduction in connecting time would have significant impact on the transshipment volume for Seoul/Incheon airport. On the other hand, reducing airport charges may not be the most effective strategy to attract more air cargo traffic from other Northeast Asian airports.

6. Summary and Conclusions

Northeast Asia (NEA) region is home to three of the top five air cargo airports in the world in 2003: Hong Kong ranked 2nd, Narita 3rd and Incheon 5th. The governments in the NEA countries have been actively pursuing economic policies that would help develop designated regions in their respective countries into global or regional transport and logistics hub. The ability of the airports in these designated regions to attract carriers and air cargo traffic, particularly with respect to transshipment traffic, is crucial to the establishment of a transport and logistics hub.

---

[7] The use of model (B) produces similar results.

[8] The geographical differences are taken into account by including the O-D distance variable in the set of instruments.

[9] The average connecting time in Seoul/Incheon was 2.25 hours

Many factors affect an airport's ability to attract transshipment cargo traffic, including the airport's current traffic flow patterns; airport infrastructure capacity and activities; linkage with regional and intercontinental airport network; service quality; and airport cost factors. Based on a unique data set of 760 air cargo transshipment routings to/from the Northeast Asian region in 2000, this paper applies an aggregate form of multinomial logit model to identify the critical factors influencing air cargo transshipment location choice decisions. The analysis focuses on the trade-off between monetary cost and time cost while considering other variables relevant for choice of transshipment airport. Our results indicate that the choice of transshipment location is more sensitive to connecting time at an airport than airport charges. On the basis of Boeing 747-400 aircraft, a one-hour reduction in connecting time would be more effective than a US$1,300 reduction in airport charges in attracting transshipment traffic. These results suggest that investing money and efforts in reducing connecting time at airports would be a more effective strategy than subsidizing airports to reduce airport charges, even if it means that airports have to increase airport charges to raise the necessary capital for capacity expansion and automation including EDI system in order to reduce connecting time.

Our model was estimated using route-specific aggregate data for each intercontinental origin-destination pair (to and from Northeast Asian region) compiled from the published sources. For future research, there is a need to use revealed and/or stated choices of the air cargo routing decision markers (shippers, forwarders, consolidators, airlines, etc.). Such micro data and survey-based data tend to be more time consuming and expensive, but they are likely to reveal the choice criteria that decision maker use more closely than our current model which is based on route-specific aggregate data. At least, such micro data can be used to verify the robustness of our findings. Needless to say, there is a need to expand our analysis to other regions and continents such as to/from Europe, to/from North America, etc.

References:

Berechman, J., Shy O., 1996, "The Structure of Airline Equilibrium Networks," in J. van den Bergh, P. Nijkamp, and P. Rietveld (eds.), Recent Advances in Spatial Equilibrium Modeling: Methodology and Applications, Amsterdam: Springer.

Berry, S., 1994, "Estimating discrete-choice models of product differentiation," Rand Journal of Economics, Vol. 25: 242-62.

Boeing Commercial Airplanes, 2002, World Air Cargo Forecast, 2002-2003, http://www.boeing.com/commercial/cargo/flash.html

Brownston, D., Train, K., 1999, "Forecasting New Product Penetration with Flexible Substitution Patterns," Journal of Econometrics, Vol. 89, No. 1-2: 109-29.

Caves, R., 1996, Multinational enterprise and economic analysis, Cambridge, Cambridge University Press.

Cheung, W., et. al., 2002, Increasing the Competitiveness of the Air Cargo Industry in Hong Kong, IFT Research Report, GSP/48/00.

Cullinane, K. Toy, N., 2000, "Identifying influential attributes in freight route/mode choice decisions: a content analysis", Transportation Review, Vol.36, No. 1, 41-53

Doganis, R., 2002, Flying Off Course: The Economics of International Airlines, Harper Collins Academics, London, UK.

Douglas, G W., Miller III J., 1974, "Quality Competition, Industry Equilibrium, and Efficiency in the Price-Constrained Airline Market," American Economic Review, Vol. 64, No. 4: 657-69.

Fernandez, J.E., de Cea, J., Soto, A., 2003, "A Multi-modal supply-demand equilibrium model for predicting intercity freight flows ", Transportation Research Part B, Vol. 37, No. 7, 615-640

Fujita, M., Mori, T. 1996, "The role of ports in the making of major cities: self-agglomeration and hub-effect," Journal of Development Economics, Vol. 49: 93-120.

Hansen, M., Kanafani, A., 1990, "Airline Hubbing and Airport Economics in the Pacific Market," Transportation Research, Vol. 24A (3): 217-230

Hendricks, K., Piccione, M., Tan, G., 1995, "The Economics of hubs: the case of monopoly," Review of Economic Studies, Vol. 62: 83-99.

Hoang, T., 2002, "Planning for the Future in an Uncertain Environment", a presentation at the 27th Annual FAA Commercial Aviation Forecast Conference, March, 2002

International Air Transport Association, 2001, The Air Cargo Tariff 2001, IATA Netherlands Data Publications

Konishi, H., 2000, "Hub Cities: city formation without increasing returns," Journal of Urban Economics, Vol. 48: 1-28.

Krugman, P., 1993, The hub effect: or, threeness in international trade. In: Ethier, W. J., Helpman, E., Neary, J P. (Eds), Trade Policy and Dynamics in International Trade, Cambridge University Press, Cambridge: 29-37.

Malchow, M.B., Kanafani, A., 2004, "A disaggregate analysis of port selection", Transportation Research Part E, Vol. 40, No. 4, 317-337

Mori, T., Nishikimi, K., 2002, "Economies of transport density and industrial agglomeration," Regional Science and Urban Economics, Vol. 32: 167-200

Oum, T H., Park, J H., 2004, "Multinational Firm's Location Preference for Regional Distribution Centers: Focus on the Northeast Asian Region," Transportation Research Part E, Vol. 40, No. 2, 101-121

Oum, T H., Zhang, A., Zhang, Y., 1995, "Airline Network Rivalry," Canadian Journal of Economics, Vol. 28 (4a): 836-57.

Shaw. S, 1999, Airline Marketing and Management, Fourth Edition, Ashgate, England

FIGURE 1

Direct and Transshipment Shares of Air Cargo: North America - Northeast Asia

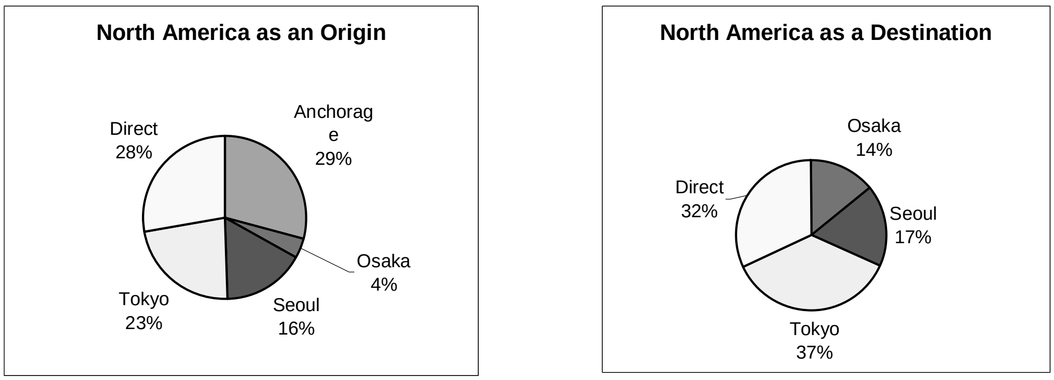


FIGURE 2

Direct and Transshipment Shares of Air Cargo: Europe - Northeast Asia

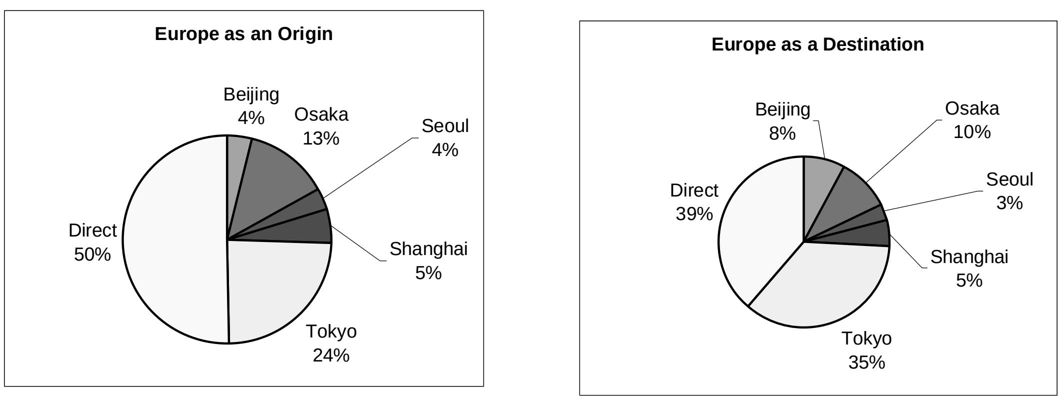
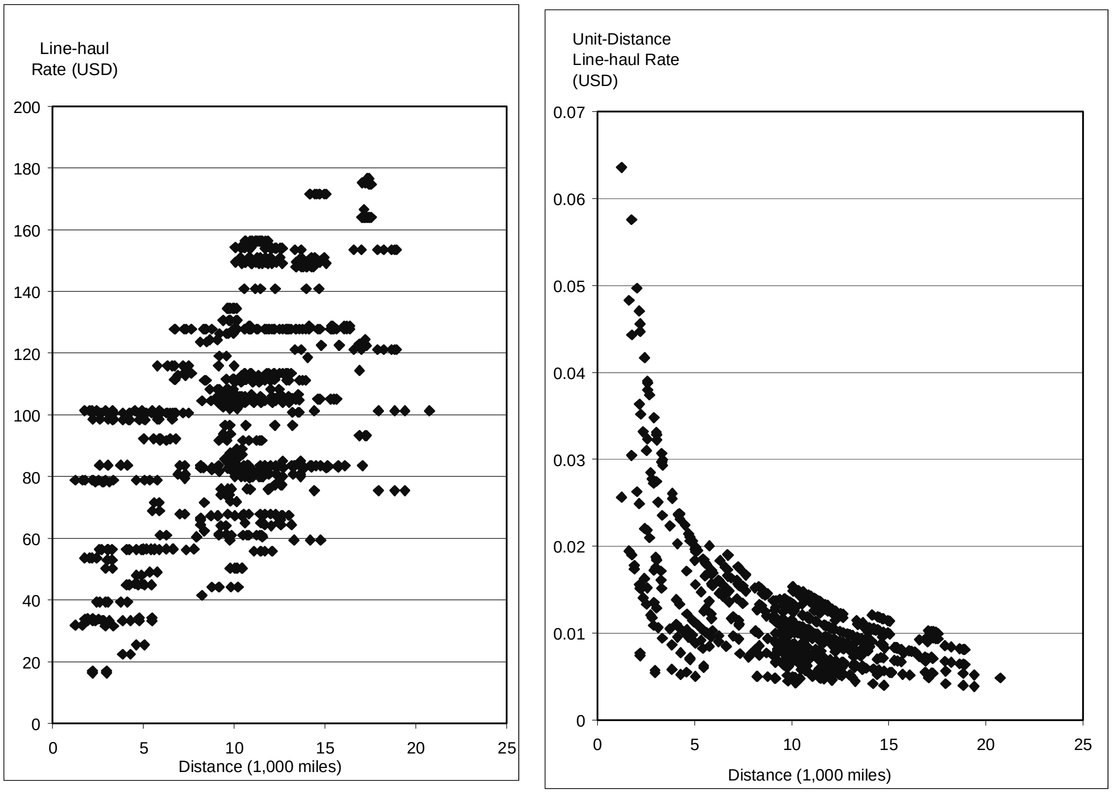
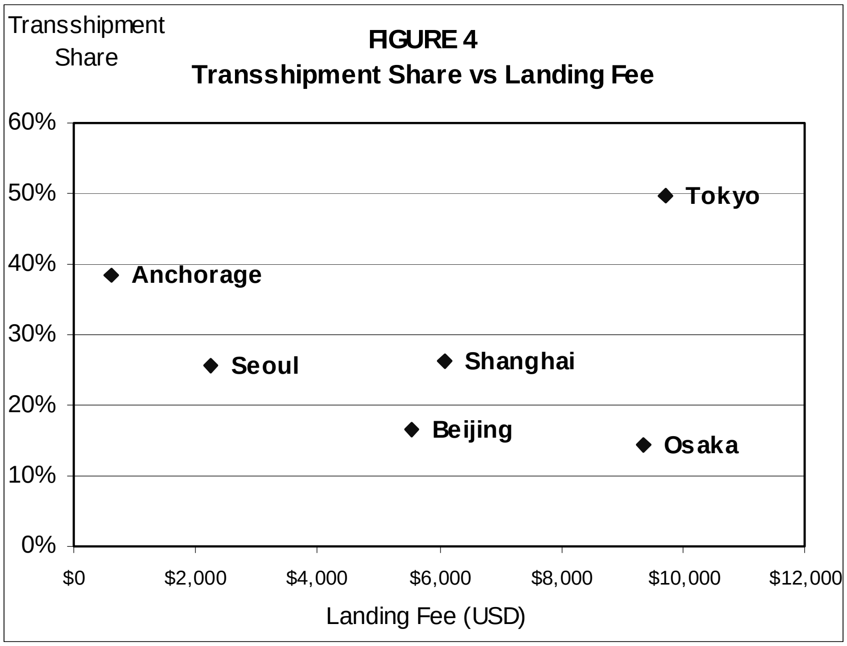


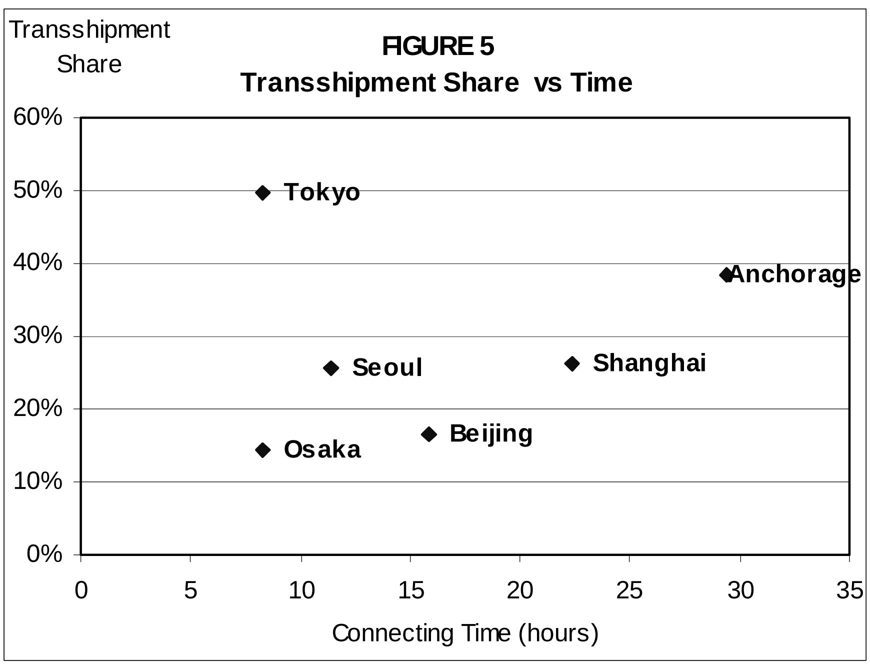
FIGURE 3

Line-haul rates and Distance



Source: International Air Transport Association, 2001


Transshipment Share
FIGURE 4
Transshipment Share vs Landing Fee
60%
50%
40%
30%
20%
10%
0%
Tokyo
Anchorage
Seoul
Shanghai
Beijing
Osaka
$0
$2,000
$4,000
$6,000
$8,000
$10,000
$12,000
Landing Fee (USD)


Transshipment Share
FIGURE 5
Transshipment Share vs Time
60%
50%
40%
30%
20%
10%
0%
Tokyo
Anchorage
Seoul
Shanghai
Beijing
Osaka
0
5
10
15
20
25
30
35
Connecting Time (hours)

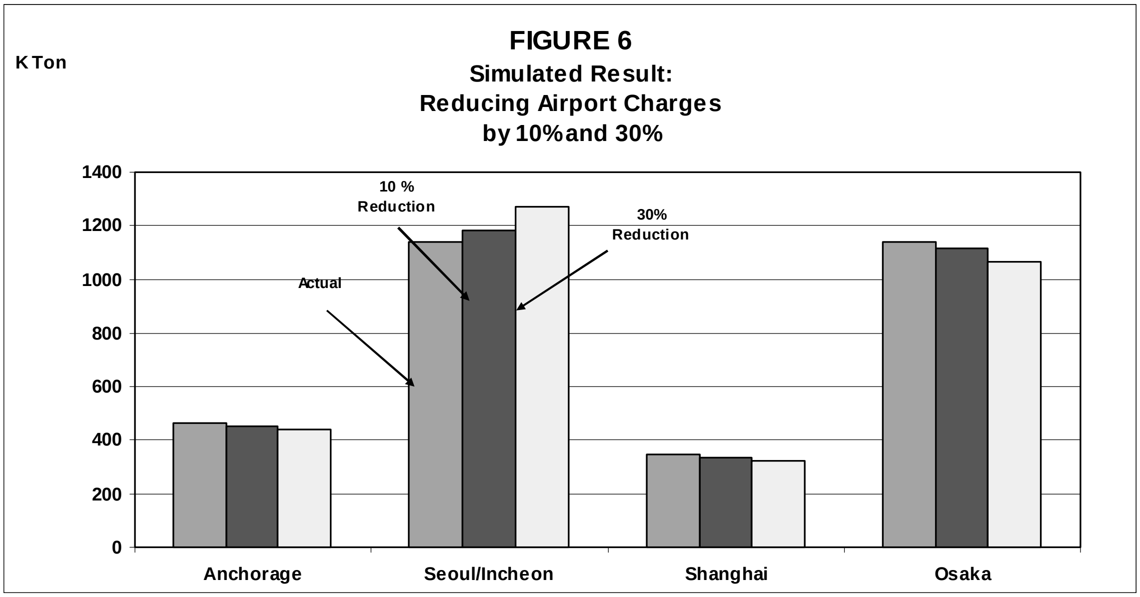


FIGURE 6
Simulated Result:
Reducing Airport Charges
by 10% and 30%
K Ton
1400
1200
1000
800
600
400
200
0
10 %
Reduction
30%
Reduction
Actual
Anchorage
Seoul/Incheon
Shanghai
Osaka

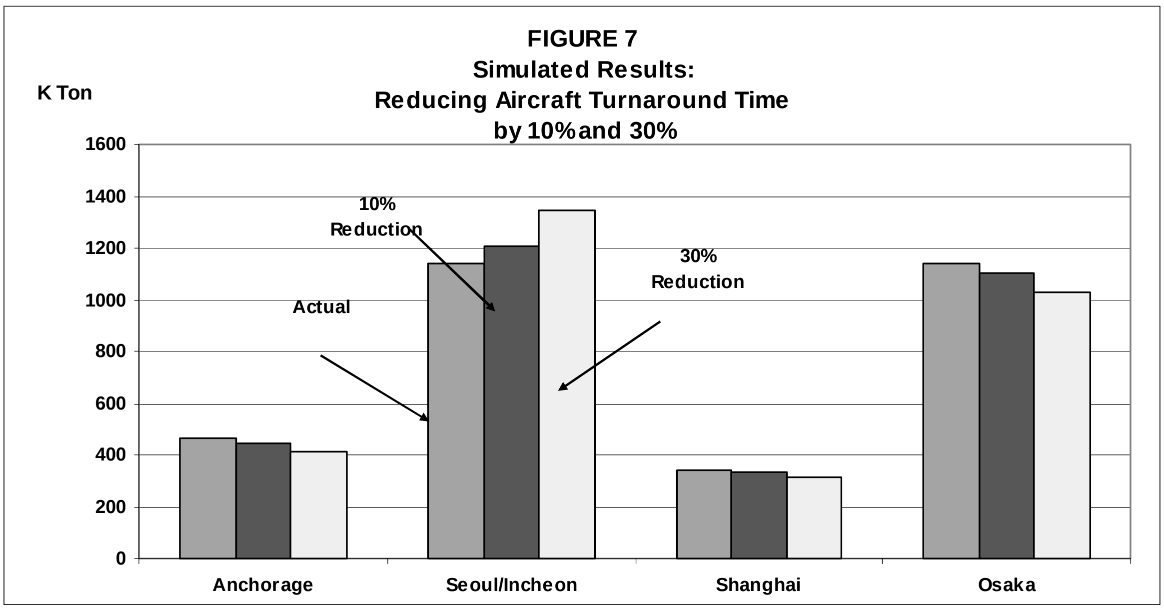


FIGURE 7
Simulated Results:
Reducing Aircraft Turnaround Time
by 10% and 30%
K Ton
1600
1400
1200
1000
800
600
400
200
0
10%
Reduction
30%
Reduction
Actual
Anchorage
Seoul/Incheon
Shanghai
Osaka

TABLE 1

CHARACTERISTICS FOR MAJOR AIRPORTS
2000

Port	Landing fee* (USD)	Run (#)	Capacity (KT per year)	Length of Runway (m)	Cargo Terminal Area (m^2)	Througputs (KT)	Average hours for L/UL & Customs
Atlanta	512	4	1000	3600	47740	272	4.5
Anchorage	606	3	4000	3800	111000	1884	5
Los Angeles	1007	4	3100	3650	185901	1023	5
Bangkok	1114	2	902	3700	115969	868	5
London	1552	3	1500	4000	94000	1402	4
Chicago	1576	7	2000	3900	190451	750	4
Seoul	2249	2	2700	3750	183158	1891	5
Frankfurt	2672	3	1600	4000	22000	1710	4
Singapore	2819	2	2500	4000	640000	1705	5
Paris	4485	4	2000	4215	299000	1611	4
New York	4646	4	2000	4400	106490	1339	5
Amsterdam	5144	4	1500	3500	270000	1267	4.5
Beijing	5547	2	300	3800	72800	557	5
Shanghai	6084	2	1750	4000	146200	613	5
Sydney	6292	3	1500	3962	140000	590	5
HongKong	6905	2	3000	3800	28000	2001	5
Osaka	9371	1	1400	3500	111940	864	4.5
Tokyo	9700	2	1380	4000	311300	1842	5

* The landing fees listed here are typical charges for a Boeing 747-400.

TABLE 2

Route Choice Estimation Results

	(A) 2SLS Base		(B) 2SLS Gravity	
	Est.	Std.	Est.	Std.
Line haul cost	-0.002	0.010		
Landing Fee	-0.026	0.018	-0.039 **	0.018
Connecting Time	-0.143 **	0.033	-0.179 **	0.056
Throughput	-0.759	0.717	-1.336 *	0.790
Distance			0.30	0.58
Line haul cost for Tokyo	0.008	0.015		
Landing Fee for Tokyo	-0.059	0.153	-0.079	0.222
Connecting Time for Tokyo	0.259	0.285	0.545	0.470
Distance for Tokyo			-0.474	1.223
No. Observations	760		760	
R-squared	0.41		0.28	
First stage F statistics	477.59 **		273.02 **	
J statistics (D.F.)	16.76 * (7)		15.15 (9)	