An Air Cargo Transshipment Route Choice Analysis

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Abstract

Using a unique feature of air cargo transshipment data in the Northeast Asian region, this paper identifies the critical factors that determine the transshipment route choice. Taking advantage of the variations in the transport characteristics in each origin-destination airports pair, the paper uses a discrete choice model to describe the transshipping route choice decision made by an agent (i.e., freight forwarder, consolidator, and large shipper). The analysis incorporates two major factors, monetary cost (such as line-haul cost and landing fee) and time cost (i.e., aircraft turnaround time, including loading and unloading time, custom clearance time, and expected scheduled delay), along with other controls. The estimation method considers the presence of unobserved attributes, and corrects for resulting endogeneity by use of appropriate instrumental variables. Estimation results find that transshipment volumes are more sensitive to time cost, and that the reduction in aircraft turnaround time by 1 hour would be worth the increase in airport charges by more than $1000. Simulation exercises measures the impacts of alternative policy scenarios for a Korean airport, which has recently declared their intention to be a future regional hub in the Northeast Asian region. The results suggest that reducing aircraft turnaround time at the airport be an effective strategy, rather than subsidizing to reduce airport charges.

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1. Introduction

Asian countries experienced the strongest growth in the international air cargo business after the recovery of the recent financial crisis. In 1999, the Asian region enjoyed export volume rising by 30.3 per cent, and cargo revenues by 45.2 per cent. The Republic of Korea saw particularly strong growth in export volumes and yields, and the region's two main airports - Hong Kong and Tokyo - were the second and third busiest freight handlers in the world. This trend is likely to sustain as China's economy consistently grows with their entry to the WTO, despite of global economic slowdown, and the influential Japanese economy spiraling downward.

Due to the surge in demand, along with the freer international aviation market in the Northeast Asian (hereafter NEA) region, the NEA countries start contemplating on aggressive competition to attract new airfreight carriers. Their efforts are reflected by the current and future expansion plans released by those countries. China has announced that they will expand PuDong airport to 5 million tonnages from the current capacity of 0.75 million within the next two decades. The capacity of Japan's Kansai airport is planned to increase more than double. Korea also has made considerable investments: They have constructed a new international airport at Incheon, and two seaports at Busan and Kwangyang.

There is an important implication for a country to become a global or regional transport hub. History on the evolution of cities such as Rotterdam and Hong Kong witnesses that a positive feedback link exists between the activity of multinational corporations (MNC's) and the success as a transport hub in the recipient country. A transport hub attracts MNCs to concentrate their logistics and distribution functions in the country. Such high value added activities increase not only their employment, and their domestic income, but also traffic volumes passing through the hub airport. At the same time, the increase in the transport volume at the airport reinforces the incentives of other MNCs to locate their logistic centers in that country. Those countries that intend to develop hubs hence face a "chicken and egg" problem: Whether to entice MNCs first by creating an incentive scheme, or to increase the transport volume first to become a hub, and then attract MNCs. While several existing studies investigate determinants of MNCs location choice (surveyed in, for example, Caves, 1996; Oum and Park, 2002), a severe lack of empirical studies on this topic remains.

The purpose of this paper is to offer the first empirical study to analyze the determinants of international air cargo traffic flows with an application to the NEA region. Obviously whenever a direct shipping route is available, holding a line-haul rate fixed, a freight forwarder prefers to choose direct rather than transshipment. In order to analyze the

tradeoff between values of time and money from the eyes of freight forwarders, consolidators, or large shippers, we solely focus on the transshipment route choice in the analysis. This limited scope of our analysis, however, does not bias estimation results, because the majority of origin-destination (hereafter O-D) shipment volumes go through a transshipment port in the NEA region. A unique feature of our air freight transshipment data in the NEA region in the year of 2000 provides us with an interesting experiment as to the identification of critical factors determining the freight flows. The data contain aggregated air cargo transshipment volumes originating from and destined for the NEA area, along with airport characteristics and airfreight fares. The paper uses a discrete choice model of an agent (i.e., a freight forwarder, a consolidator, or a large shipper) who makes a routing choice, and identifies critical determinants of transshipment freight flows. The analysis incorporates two major factors, monetary cost (such as line-haul cost and landing fee) and time cost (i.e., aircraft turnaround time, including loading and unloading time, custom clearance time, and expected scheduled delay), along with some other controls. The estimation method considers the presence of unobserved attributes, and corrects for the resulting endogeneity by use of appropriate instrumental variables. The paper finds that transshipment volumes are rather sensitive to the time cost than monetary cost: The reduction in the aircraft turnaround time by one hour would be worth the increase in the airport charges by more than $1000. This finding implies that it would be more effective to promote airports by reducing aircraft and air cargo turnaround time, rather than reducing airport user charges.

Using the estimation model and results, the paper conducts simulation exercises to measure the effect of airport's price and non-price policies on the transshipment volumes. The paper focuses on Korea in particular to investigate the impact of their counterfactual policy changes. Two policy alternatives are considered, one for airport charges, and the other for aircraft turnaround time. The simulation exercises find that, a landing fee would have to be cut half in order for Seoul to increase its share by 20%, while the 30% improvement of the aircraft turnaround time would do the same job. This finding suggests important policy implications to airport authorities or local governments: Investing money for reducing turnaround time at an airport is an effective strategy, rather than subsidizing the airport to cut user charges. When capital is in short supply for investment, it may make sense to raise airport charges, and then to use their operating profits for capacity expansion and automation including electronic data interchange (hereafter EDI) system.

A growing body of theoretical work finds the causal relationship between MNC location patterns and transport network structure. Two major strands in the literature reflect the nature of the chicken-egg problem discussed above. One strand is to examine the designs of transport networks when the economies of density exist. Hendricks, Piccione, and Tan (1995) find that the economies of density often lead to hub-and-spoke networks. Oum, Zhang, and Zhang (1995) find that the hub-and-spoke system may be used as entry deterrence, while Berechman and Shy (1996) show that it can also accommodate entry if the passenger's time value and aircraft capacity constraints are taken into account. The other strand focuses on how industrial location patterns emerge under the given structure of transportation networks. The work includes Krugman (1993), Konishi (2000), and

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Fujita and Mori (1996). Mori and Nishikimi (2002) analyze the interaction between the two forces. The paper makes a contribution to the empirical side mostly concerned with the first group of the literature.

The paper is organized as follows: Section 2 describes air freight business. This section also introduces a data set and important explanatory variables. A discrete choice model discussed in Section 3 uncovers determinants of the transshipment volumes originating from and destined for the NEA region. Section 4 presents estimation results. Section 5 conducts simulation exercises focusing on a Korean airport. Section 6 concludes the paper's findings.

2. Air Freight Business

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

The logistics of moving freight is more complicated than that of moving passengers. It involves packaging, preparing documentation, arranging insurance, collecting freight from the shipper, 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 the shipper 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 freight business is inherently competitive. This is because most freight, except for emergency freight, is indifferent to the routings made to move 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 with several hours of transshipment at one of those airports, provided that the shipment arrives at Kuala Lumpur within the expected time. Few passengers would put up with such a journey. Thus, in most cases, a freight forwarder can use numerous routings and airlines to get its destination. The flexibility in routing choices ensures inter-airport as well as inter-airline competition that is absent for passengers on the same route.

Airfreight transshipment is a very important aspect of the air cargo industry in the NEA region. Figure 1 shows direct and transshipment shares of air cargos delivered between North America and the NEA countries in the year of 2000. Roughly 70 % of airfreight reaches final destinations via one or more transshipment points. Anchorage has the highest share of transshipment air cargoes originating from the North America, because many U.S. airlines use short- or middle-haul aircrafts to collect their freight to

consolidate at Anchorage, and then use long-haul aircrafts to deliver to the NEA region. Tokyo takes half of the transshipping shares when freight is shipped from the NEA. Figure 2 presents the share data between Europe and the NEA area. A high share of 60 % of the cargo traffic from the NEA region and Europe is transshipped on the way to the destination. Again the table shows that Tokyo plays a dominant role in the freight transshipment.

We focus on the air cargo movement between origin and destination gateway airports, rather than their real origin and destination points, primarily because our data do not contain the record on where the shipment comes to and goes from gateway airports. Table 1 lists major airports and their main characteristics related to the airfreight traffic in the NEA region. By limiting our analysis on the air cargo movement between gateway airports only, we implicitly assume that there is no alternative routing choice that involves inter-modal movement[1]. This should not impose any serious problem, however, as such inter-modal movements are rather limited in airfreight transport.

Table 1 lists the airports under our study in descending order of landing fees for Boeing 747-400 with the gross takeoff weight of 395 tones. A casual observation on the landing fees informs us 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 USD 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 B 747-400 as indicated by the length of runways[2]. 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 detailed later in this section.

Conditioned on the choice of transshipment, freight forwarders must consider several cost factors to decide which airport to stop over in order for them to minimize the total shipping cost. The cost factors are roughly grouped into two categories: monetary cost and time cost. Monetary cost is equivalent to the sum of airport charge and freight line-haul rate. Line-haul rate is aircraft operation cost, and depends on the distance of each route, and the number of required transshipment. In many cases, transshipment is made only once, and our data contains only such case.

Time cost comprises following four factors: cruising time (which must be highly correlated with the route distance), loading and unloading time, and customs clearance and other processing time.

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[1] Inter-modal movement refers to the use of more than mode of transport. For example, for shipments from New York to Kuala Lumpur, some shippers may transport by air via Hong Kong, whereas others might fly their shipments to Singapore first, and then truck to Kuala Lumpur.

[2] B747-400 requires runways with a minimum length of 2800 meters.

The next three subsections examine each of the factors in detail. Section 2.1 describes monetary costs, and Section 2.2 time costs. Section 2.3 discusses other possible unobserved factors that may influence the freight forwarders transshipment route choice.

2.1. Monetary Costs

This subsection discusses two main components of the monetary costs: (A) line-haul rate and (B) airport charges.

A. Line-haul rate:

The data on line-haul rates used in this paper are the list price by route published by IATA (the International Air Transport Association), TACT book 2001. Price is a key element of airline services. The actual transaction fares are sometimes discounted from the list fares, especially for large freight forwarders, and the extent of discount reflects the degree of bargaining power. The actual transaction fares are made confidential, and it is very difficult for researchers to obtain such data. Thus we use the listed line-haul rates in the estimation.

The distribution of all the line-haul rates in the data set is presented in Figure 3. There is a clear trend that the line-haul rates increase with distance. The unit-distance rate indicates economies of scale with distance, indicating the presence of fixed cost. Notice that short-haul shipping is within the Asia region, the medium-haul is mostly the shipment to and from the U.S., and the longest is with Europe.

B. Airport Charges:

Another significant element of freight costs is landing fee. Freight forwarders have to pay a share of landing fee based on the weight of their airfreight. While airlines have tried to hold down the increase in landing fees in particular countries acting through IATA, an individual airline has little scope for negotiating better rates for itself.

Airport charges are shown in Table 1, and were briefly discussed earlier in this section. Many Asian airlines have relied heavily on cargo revenue, and dedicated cargo carriers do not play a big role in Asia, unlike those in the United States. For instance, EVA generates 39.4% of its revenue from the cargo business, and Cathay Airline generates 26.4%, while the United Airlines generates only 5.2% from air cargo. Though several airlines, such as Korean Air and China Air own dedicated cargo aircrafts, much of airfreight is still carried in the belly of passenger aircraft.

The level of airport charge depends partly on the costs at the airport and partly on whether the airport or the government is trying fully to recover those costs or even make a profit. As a result, airport charges (landing fees) vary enormously across different

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airports. The highest landing fee is charged at $USD 9,700 by Narita International airport, Tokyo, and the lowest is at $USD 512 by Anchorage. Because of the limited data availability of landing fees, we use the B747-400 landing fee as a representative airport charge. The use of the landing fee data is not completely satisfactory in that they are not able to capture the differences in the load factor. If these missing variables are roughly correlated with the airport size, then we could use a random coefficient model introduced by Brownstone and Train (1999). Their method allows us to interact the landing fee with the airport size with an explicit distributional assumption on freight forwarders' heterogeneity. Though the application of this method is beyond the scope of this paper, it would be an interesting extension for future research.

2.2. Time Costs

This subsection lists three important elements of the time costs: (A) cruising time, (B) loading/unloading and customs clearance time, and (C) the time cost caused by scheduled delay.

A. Cruising Time
As easily expected, cruising time is closely determined by the route distance. Thus, the variable, line-haul rate, takes care of the cruising time in the estimation.

B. Loading and Unloading (L/UL) Time, and Customs Clearance Time
In many countries, aircrafts have to go through the customs, even though the cargoes just pass through a transshipping port. They also spend time to load and unload their cargos at the airport. A freight forwarder has to consider these time costs upon its choice of a transshipment route. If the average customs clearance time takes too long at some airport, a freight forwarder is likely to avoid the route given the other features of the airports. The data on the sum of U/UL time and customs clearance time are presented in Table 1. It appears that the sum of these time costs does not vary across the airports.

C. Scheduled Delay [3]
The air cargo service is enhanced by more frequent departures and greater likelihood of the reloaded cargos on preferred flights. The data contain the numbers of air passenger trips per week by airport for both incoming and outgoing flights by route. We use the idea of Douglas and Miller (1974), and calculate the expected scheduled delay as the inverse of the frequency. The expected schedule delays in arrival and departure are different across city pairs. We calculate the expected maximum hours of scheduled delay by taking a sum of scheduled delays on arrival and departure.

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[3] Though UPS and Fedex started operating at Incheon airport in Korea, charter flights are not yet popular in the NEA region. Thus we solely focus on scheduled flights in this paper.

Freight forwarders would shy away from choosing the airport with longer expected scheduled delay, holding the attributes of the other airports constant. The scheduled delay indicates how many hours on average an air cargo has to wait at the airport before catching the next flight. During the waiting period, the freight has to be reloaded, and clear the customs. For some route, the customs clearance takes so long that the freight has to stay more than the minimum expected scheduled delay time. If this is the case, the freight has to be held at the airport until the next available scheduled flight. Therefore, we calculate the expected total time cost at a particular airport j as follows:

$$(n_{ij}+1)*(\text{expected scheduled delay})_{ij} > (\text{L/UL time} + \text{custom clearance time})_j > n_{ij}*(\text{expected scheduled delay})_{ij}$$

where n_{ij} is the number of scheduled flights that have to be missed for route i at airport j in order for the airfreight to complete being reloaded and processing customs clearance. The first term of the above equation, $(n_{ij}+1)*(\text{expected scheduled delay})_{ij}$, is defined as the time cost, the length of time that the aircraft has to stay at airport j on route i. The data on frequency are by O-D ports pair. The time cost is obtained as the expected maximum hours of stay at the airport, that is, the sum of the scheduled delays of two routes, one with the origin, and the other with the destination. The summary statistics of this variable are in Table 2.

2.3. Throughputs

Throughput is the total volume of traffic processed through an airport. This is an important determinant in explaining the transshipment route choice in two ways. First, the import volume increases with the size of hinterland demand, and thereby more aircrafts stop over and drop off freight that meets the demand. Secondly, the throughput size serves as a good indicator of the attractiveness of the country in the eyes of MNCs who are looking for new subsidiary locations. The literature on economic geography (surveyed in, for example, Fujita, Krugman, and Venables, 2000) finds the agglomeration effects of MNC's location choice. We use the amount of throughput as a proxy for the size of hinterland demand. Table 1 shows the throughput data by airport in the year of 2000. High throughputs in Hong Kong and Anchorage are mostly due to freight transshipment, and that in Tokyo may be due to the size of domestic demand.

2.4. Casual Observations across Variables

This subsection provides simple correlations between the transshipment volumes and critical explanatory variables. Section 4 formally estimates such relationships with a discrete choice model.

We select five airports as important transshipment points in the airfreight traffic in the NEA region: Beijing, Bangkok, Osaka, Shanghai, Seoul, and Tokyo. We include Bangkok, because this is a transport hub for airfreight between the north and south Asian regions. Therefore, Bangkok may not be in the same competition as the rest of four airports. Hong Kong has to be excluded from the data, the reason being that no data are available on the airfreight flows with inland China. Since Hong Kong is virtually a gateway port to China, it is not desirable for us to use the Hong Kong data without the data of Chinese cargo freight.

Figure 4 is a scattered diagram indicating the relationship between transshipment shares and landing fees (in unit of USD) for the selected airports. We calculate the transshipment share for a particular airport by first calculating the proportion of the transshipment volume passing through the airport in each pair of origin and destination, and then averaging them over all the combinations of origin and destination. Thus this transshipment measure is based on the sub-population of the O-D freight volume, and does not take into account the direct shipment.

The figure illustrates that, except for Tokyo, there is a negative correlation between landing fee and transshipment share. Tokyo has a high share with high landing fee, making itself distinctively different from other airports.

Figure 5 presents how the transshipment share is related to aircraft turnaround time. The figure reveals, again save for Tokyo, a positive relationship between the share and turnaround time. One might think that this relationship appears odd because longer turnaround time increases the share. The figure, however, should not be interpreted as the causal effect of time. Rather the figure indicates that the turnaround time, or service frequency, may be endogenous: The increase in share would exacerbate congestion, forcing the aircraft turnaround time longer. In the estimation, we carefully control for this endogeneity by using appropriate instrumental variables.

Both Figures 4 and 5 find that Tokyo's Narita airport is very different from other airports: Tokyo has a high share yet with highest landing fee and shortest aircraft turnaround time. Historical reasons place Tokyo as rather an outlier in the figures (Hansen and Kanafani, 1990). The introduction of jets into commercial service and high economic growth in Japan provided Tokyo with the only major Asian destination with the United States in the late 1950s. Tokyo's dominance 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 witnessed that Tokyo's dominance is slowly changing, but still Tokyo has enjoyed sitting on the laurel from the past. In account of this Tokyo's historical perspective, we create a dummy variable to deal with Tokyo differently from the other airports.

2.5. Unobserved Variables

We have discussed two major factors, monetary and time costs, which likely change the relative transshipment shares. Other factors may also likely influence the freight forwarder's route choice. We discuss three such factors in this subsection: congestion, the international aviation regulation, and technology advance in custom administration. Although we do not have data of these three variables, there is a concern with resulting endogeneity problem that presumably bias estimation results. We discuss the source of the endogeneity problem in this subsection, and a correction method in Section 4.2.

(1) Congestion

Congestion likely correlates with scheduled delay, because, an airport becomes crowded with the number of scheduled flights, given the limited capacity of the airport and efficiency of the customs clearance. This congestion factor, since unobservable, would likely remains in the error term obtained from estimation. We therefore concern with a correlation between the error (which is partly reflected by congestion) and the explanatory variable, scheduled delay. In the estimation, we correct for this possible endogeneity as discussed in Section 4.

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

Over the years, each country has signed a series of bilateral air services agreements with other countries aimed at regulating the operation of air transport services. Although a liberal type of bilateral agreement (i.e., the Bermuda type) has become more widespread, as we see in the recent Hong Kong's experience, the agreement sometimes does not preclude airline pooling agreements, which effectively restrict capacity competition. Nor do they preclude subsequent capacity restrictions imposed arbitrarily by governments to prevent foreign carriers from introducing a new aircraft type or to limit increases in frequencies (See Cheung, et. al, 2002, for the recent case in China). Many features of a state involvement in aviation are not clearly observable.

Bilateral air services agreements and inter-airline agreements influence the airline frequencies to be operated. 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. Since we do not have an appropriate measure of this state involvement in aviation, these aspects of regulation may be captured by the unobserved variable, ξ. Therefore, there is a concern for possible endogeneity in that the expected scheduled delay (calculated from the frequency data), and the error may be correlated one another. We discuss a set of instruments to correct this endogeneity problem in Section 3.2.

(3) Advance in Customs Administration

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Historically, revenue raising was a major function of customs administration. Importance of this role diminishes as tariff barriers are reduced. Instead, customs administration plays an important role in attracting international airfreight. Unpredictable delay in customs clearance, or unexplained changes in the classification of goods disrupt efficient logistic flows, and thus hinder the hub development in air cargo transshipment. The technology, such as EDI system, makes the customs procedure simplify by computerizing the shipment information, and makes it efficient by allowing for pre-clearance of the shipment. Some airports, such as Singapore, created a bonded zone area so that the transshipment goods can avoid customs. Though customs clearance in many airports is yet processed manually, some other airports strive to simplify the processes. Unfortunately we do not observe the extent of efficiency achieved by each of the airports regarding customs clearance process. Since the efficiency of customs is often measured by time, the 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 fare to raise their revenue. This generates another concern for the endogeneity with the line-haul cost variable. A set of instruments to correct the endogeneity issue is discussed in Section 4.2.

3. Estimation Model

This section introduces an estimation model to describe the route choice process made by freight forwarders. The choice model is derived from a random utility discrete choice model of freight forwarders. 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.

Each freight forwarder, i, is assume to maximize the following indirect utility function by choosing the route, j, among a set of alternative transshipping routes in a particular origin-destination gate ports 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 freight from the origin to the destination. The utility can be interpreted as a negative of the transshipping cost. The vector, X_j, includes the variables that reflect the freight forwarder's transshipment route choice. A k-the component of this vector is denoted by J_{oke}. The previous section discusses that the monetary and time costs are the two most important determinant factors in the route choice. The time cost variable indicates how many hours for which a representative air cargo has to stay at a particular airport. For monetary costs, we use following two measures: line-haul fare, and landing fees. Detailed description of the variables is found in Sections 2.1 and 2.2. We also include as

explanatory variables a size of hinterland demand (i.e., throughput), and the Tokyo dummy interacting with line-haul cost, landing fee, and time cost. As discussed in Section 2.3, the explanatory variables do not cover all the important factors affecting the transshipping routing choices made by freight forwarders. We therefore include an error term, ξ_j, to capture such unobserved (to the econometrician) factors with zero mean. The other error term, ε_{ij}, determines 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 should take care of the possible endogeneity problem, i.e., the correlation between some explanatory variables and ξ_j. We discuss a method for correcting the endogeneity bias in Section 3.2.

3.1. The Logit Model

In our analysis, a freight forwarder chooses a transshipment point to maximize its utility (or minimizes its shipping cost). The standard conditional logit model provides a closed form choice probability. 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 Φ_{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 (The previous work, for example, Berry (1994), uses this technique):

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

where $j \in \Phi_{O-D}$. Since the 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:

$$\ln s_j - \ln s_l = \sum_k (X_{jk} - X_{lk}) \beta_k + (\xi_{jk} - \xi_{lk}) \quad (1)$$

This 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 airports. 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, $(\xi_{jk}-\xi_{lk})$. This section discusses the sources of endogeneity, and a method to correct the problem. One source of the possible endogeneity comes from the missing variables we discussed in Section 2.4. We are concerned about the possible bias from missing three variables: congestion, aviation regulation, and customs efficiency. All these missing variables could correlate with the service frequency, which we used to create a time cost variable. Furthermore, unobserved customs efficiency might also correlate with line-haul fare, through airlines market power: Some airlines may be able to charge a high freight fare with a route with efficient customs procedure, because the route would attract forwarders who concern 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 estimation, we thus use instruments that would correlate with the endogenous variables, but not with the unobserved attributes. We consider two sets of instruments. The first set of instruments used in the estimation is related to airport characteristics: length of the runways (m), and cargo terminal areas (m^2). We expect that these instruments control for endogeneity of time costs. The length of the runways indicates what type of aircrafts can land on the airport. Enough runway length is required for 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 areas may correlate with U/UL time, though the sign of correlation is ambiguous: If the terminal areas are large relative to the size of throughput volume, there may be economies of scale to making U/UL process shorter, leading to a negative correlation between these two variables. If there are diseconomies of scale, a sign would be positive. Those two variables may likely be exogenous to congestion, aviation regulation, and customs efficiency. Thus they can serve as instruments in our estimation.

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

In a model with exogenous airport characteristics, the characteristics of other competing airports are also appropriate instruments. With some regional market power by airport, the transshipment volume depends on the relative attractiveness to the other airport characteristics. Holding the characteristics of a particular airport constant, the airport would lose transshipment freight share as a characteristic of other airports improves. The characteristics of other airports are thus related to the service frequency, but since characteristics are assumed to be exogenous, they are valid instruments. In the present study, we include in the set of instruments the sum of characteristics of the other airports in the NEA region. we assume that Anchorage does not face with effective competition from the NEA area.

4. Estimation Results

This section examines estimation results of the model (1). The definition of the variables and summary statistics are presented in Table 2. The previous subsection discusses that line-haul rate and turnaround time are likely endogenous in the estimation. Thus we use two-stage least squared method (hereafter 2SLS) in the estimation.

Table 3 shows the estimation result. The table shows two different specifications. The specifications differ in how to deal with the endogeneity in line-haul rate. The specification, (B), treats line-haul rate as an endogenous variable, the other specification, (D), uses a proxy variable, distance, to substitute for the line-haul variable. As we discussed in the Section 2.1, the line-haul cost and distance closely correlate with each other. Since a geographical distance between airports is exogenous, (D) does not require instruments for the line-haul rate. Note that we still need to control for turnaround time. The model (D) is typically called a gravity model, and frequently used for forecasting traffic flows. For each of the specifications, (B) and (D), we provide the results from OLS, for the purpose of comparison ((A) and (C) respectively).

Tokyo's Narita has been a dominant airport since the 1950s with huge hinterland demand. In order to control for this historical element discussed in Section 2.5, we add the Tokyo dummy for the variables of landing fee, turnaround time, and line-haul rate (for the models (A) and (B)), or distance (for the models (C) and (D)). We use instruments specific to Tokyo, in order to control for endogenous variables interacting with this dummy.

Table 3 finds that the model fits are not impressive at the first glance: The model explains only up to 46% of the variation in the dependent variable. Note, however, that the obtained results are within estimators: We obtain the estimators using the variations only among routes given each O-D pair. Provided that some of our data only vary by airport, but not by route, we consider that the results are satisfactory. For the 2SLS estimation, the table also shows averaged first-stage F-statistics for the explanatory power of the instruments, conditional upon the included exogenous variables. The F-statistics 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 the table would not generally reject the hypothesis that some of the instruments are orthogonal to the unobserved error term with the 99-percent confidence level.

The comparison of the first two results, (A) and (B), shows that the endogeneity problem appears to be significant in the estimates of line-haul rate and turnaround time. The line-haul rate has a positive coefficient in the OLS result, whereas it is negative (but not significantly different from zero) after controlling for the endogeneity. This result indicates that the line-haul fare may be positively correlated with the variables that we do not observe in the data. We also expect that the turnaround time variable has an upward biased estimate if not appropriately controlled, because, for example, the unobserved congestion effect may be positively correlated with the time variable. The result from the 2SLS confirms our prediction: The turnaround time coefficients are lower in 2SLS by 40%.

The coefficients of the landing fee and throughput variables are both significantly different from zero in (A), but not in (B) even though they have the same signs. The throughput variable shows that after controlling for all the explanatory variables, the transshipment airport exhibits economies of density on average. This interpretation is, however, clouded by the effect of congestion.

The Tokyo dummy estimates indicate the extra effects of those variables relative to the other airports. Tokyo dummies are positive both for line-haul cost and turnaround time. The magnitude of the estimates are high enough that the transshipment share through Tokyo increases with line-haul cost and turnaround time. Some of these odd results are already manifested in the preliminary inspection of the data shown in Figures 4 and 5.

The specifications (C) and (D) estimate the gravity equation. Both estimation results are similar to the previous results that use the line-haul rate as an endogenous variable; however, the standard errors are considerably improved. Though the two 2SLS results are qualitatively the same, the absolute values of the coefficients in landing fee and turnaround time in (D) is larger than those in (B).

The comparison in the magnitudes of the landing fee and time variables show that the monetary cost is not so important a determinant factor as the time cost. The estimation result (B) indicates that, holding the other airport competitors' characteristics, and focusing on airports other than Tokyo, if an airport is able to reduce the aircraft

turnaround time by 1 hour, that effect would be worth the increase of the airport charges by $1361 ($1146 based on the estimates from (D)). This result implies that the time factor would play more effective role in influencing the transshipping volume, rather than the landing fee itself.

In light of the allocation in the airfreight cost, our estimation result makes sense. For the world's airlines as a whole, airport user charges (that is, airport charges and en route facility charges) account for just over 5 percent of their total costs. The proportion generally rises, but by small amount, for international airlines operating relatively short-haul sectors, where landings occur more frequently. For some airlines, such as KLM, the proportion dropped to just below 5 percent, while for US carriers it was generally 2-4 percent.

On the other hand, usually the airfreight business deals with the commodities with high value-added, which would be time sensitive. Most goods being shipped by air have 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. The estimation results capture this nature of the time-sensitive airfreight business.

5. Simulation Exercises

The previous section estimates what factors determine the freight forwarder's choice of transshipment routes. The estimation results reveal that the aircraft turnaround time plays a rather important role in the route choice made by freight forwarders. The previous section estimated that the reduction in the turnaround time by 1 hour is worth the increase in airport charges by more than $1000.

Based on the estimation results in Table 3, this section examines what alternative policies would be most effective for an airport to increase transshipment volumes. We are particularly interested in Korean airports, since Korea recently declared their intention to become a regional logistic hub in the NEA region. Obviously there are many policy tools for the country to achieve such a goal: designing tax incentives for MNC logistic centers, establishing protection of intellectual property rights, setting transparent regulatory environments, and so forth. This paper considers only two of such policy tools. One is airport charge, including landing fee and airport navigation charge. The other is aircraft turnaround time, due to a reduction in loading and unloading time, simplification of customs clearance procedure, and an increase in flight service frequency. We use the estimates from the specification (D) in the following exercises, however, those from the specification (B) provides a similar result.

Figure 6 shows how the transshipment volume would change with the reduction of airport charges at Seoul airport. We ask the following question in this simulation: How much transshipment volume would increase if the airport user fee were reduced by 10% or 30% from the actual. We calculate the counterfactual transshipment volumes based on the assumptions, and compare them with the actual volume. Partly due to the fact that Seoul airport charges already a lower landing fee, the impacts of airport charges would not be very significant even if the fee were cut by 30%: The increase of the volume is 11.7%, mostly switched from Kansai airport in Osaka. This result makes sense in view of the geographical proximity between the two airports (we takes into account the geographical differences by including the O-D distance variable in the set of instruments).

The counterfactual policy scenarios with respect to aircraft turnaround time are examined in Figure 7. We ask how much transshipment volume would increase if the turnaround time were reduced by 10% (i.e., 14 minutes) and 30% (i.e., 40 minutes) from the actual level. The turnaround time in Korea averaged over routes was 2.25 hours. As expected from the estimation results in the previous section, the impacts of this alternative policy would be significantly large: The volume of transshipment through the airport increased by 18.3% if the turnaround time should be shortened by 40 minutes.

The simulation results illustrate that a slight reduction of turnaround time would have a great deal of impact on the transshipment volume for airport. A policy of reducing airport charges may not be a most efficient strategy to attract more airfreight volumes from other Northeast Asian airports.

The Northeast Asian region experienced the strong growth in the international air cargo business after the recovery of the recent financial crisis. Due to this surge in demand, along with the freer international aviation market, the countries in the Northeast Asian region have started contemplating on aggressive competition to create hub airports.

With the use of the unique feature of the air cargo transshipment data in the Northeast Asian region, this paper identified the factors essential to become a transport hub airport. The paper used a discrete choice model to explain the transshipment flows in the data set. It also addressed the endogeneity issue by utilizing the appropriate instrumental variables. The estimation results found the importance to correcting for the endogeneity. They indicated that transshipment volumes are more sensitive to the length of the aircraft turnaround time: The reduction of the aircraft turnaround time by 1 hour would be worth the increase in airport charges by more than $1000 per aircraft. Simulation exercises with respect to the alternative policy scenarios for the Korean airport also confirmed this result. The paper's findings contained important policy implications to airport authorities in the Northeast Asian countries. The paper suggested that investing money for reducing turnaround time at airports be an effective strategy, rather than subsidizing airports to

reduce user charges. When capital is in short supply for investment, it makes sense to raise airport charges, and then to use their profits for capacity expansion and automation including EDI system in order to reduce turnaround time.

One avenue of the future research is to collect disaggregated data by industry product and/or by air cargo type and to check the robustness of our finding. Another avenue of checking the generality of our results is to do a similar work for transshipment hub location competition for North America and Europe.

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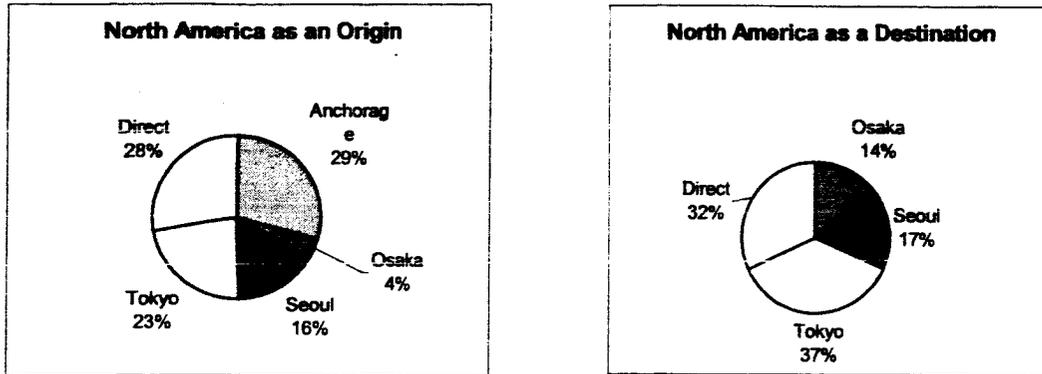Oum, T H., Park, J H., 2002, "Multinational Firm's Location Preference for Regional Distribution Centers: Focus on the Northeast Asian Region," a paper presented at the NEAEF-KOTI Conference (August: Honolulu, Hawaii).

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FIGURE 1

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

North America as an Origin

Direct 28%
Anchorage 29%
Osaka 4%
Seoul 16%
Tokyo 23%

North America as a Destination

Osaka 14%
Direct 32%
Seoul 17%
Tokyo 37%

FIGURE 2

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

Europe as an Origin

Beijing 4%
Osaka 13%
Seoul 4%
Direct 50%
Shanghai 5%
Tokyo 24%

Europe as a Destination

Beijing 8%
Osaka 10%
Direct 39%
Seoul 3%
Shanghai 5%
Tokyo 35%

21
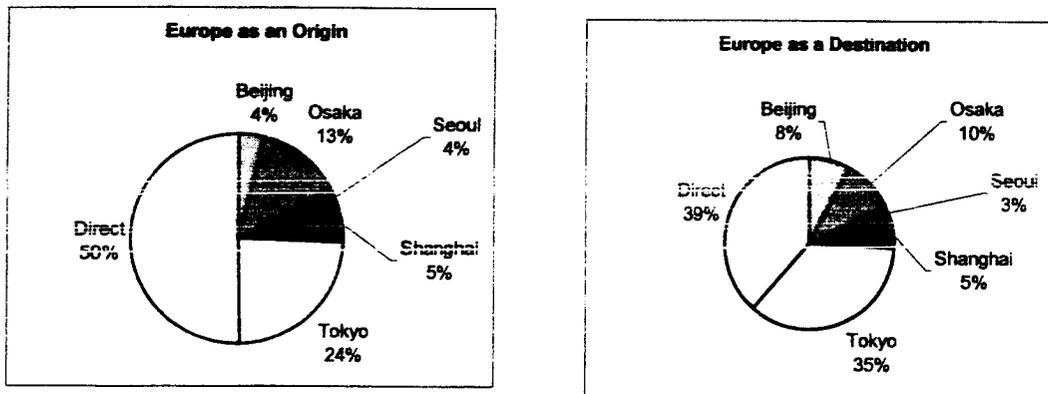
FIGURE 3
Line-haul rates and Distance

Transshipment Rate — Line-haul Rate (USD) vs. Distance (1,000 miles)

Transshipment Unit-Rate — Unit-Distance Line-haul Rate (USD) vs. Distance (1,000 miles)

Transshipment
Share

FIGURE 4
Trans-shipment Share - Landing Fee

```
0.6

0.5                                              ◆ Tokyo

0.4  ◆ Anchorage

0.3           ◆ Seoul        ◆ Shanghai

0.2
                        ◆ Beijing        ◆ Osaka
0.1

  0
     0      2000     4000     6000     8000    10000    12000
                        Landing Fee (USD)
```

Transshipment Share

FIGURE 5
Trans-shipment Share - Time

```
0.6

0.5      ◆ Tokyo

0.4                                              ◆ Anchorage

0.3           ◆ Seoul        ◆ Shanghai

0.2
       ◆ Osaka    ◆ Beijing
0.1

  0
     0    5    10    15    20    25    30    35
                   Time cost (hours)
```

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FIGURE 6

KTon

Simulated Result:
Reducing Airport Charges
by 10% and 30%

FIGURE 7

Simulated Results:

K Ton

Reducing Aircraft Turnaround Time
by 10% and 30%

TABLE 1

CHARACTERISTICS FOR MAJOR AIRPORTS
2000

Port	Landing fee (USD)	Runways (#)	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	6	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

TABLE 2

DEFINITIONS AND SUMMARY STATISTICS FOR THE VARIABLES
Airfreight in the Northeast Asian Region, 2000

Descriptions	Mean	Std. Error	Min	Max
Dependent Variable				
The volume share % on route j in the total transshipment volume in the O-D pair	22.14	25.89	0.00001	100.00
Independent Variables				
Shipping Rate (USD)	92.53	32.59	16.34	176.64
Landing Fee (USD: B747-400 with the weight of 395 tons)	52.88	31.02	6.06	93.71
Aircraft turnaround Time (hours)	14.46	17.01	4.69	91.00
Throughput by Airport (K tons)	1.18	0.58	0.56	1.89
Instruments				
Length of the Runway (meters)	3.73	0.17	3.50	4.00
Cargo Terminal Area (squared meters)	13.32	3.95	7.28	18.32
Distance from the origin port to the destination port via transshipment port (miles)	0.97	0.40	0.12	2.07
Sum of the competitors' runway length (meters)	45.04	623.49	0.00	9480
Sum of the competitors' cargo terminal area	4.55	62.75	0.00	900

TABLE 3
Route Choice Estimation Results

	(A) OLS Base		(B) 2SLS Base		(C) OLS Gravity		(D) 2SLS Gravity	
	Est.	Std.	Est.	Std.	Est.	Std.	Est.	Std.
Line haul cost	0.008 **	0.003	-0.002	0.010				
Landing Fee	-0.025 **	0.005	-0.026	0.018	-0.017 **	0.005	-0.039 **	0.018
Turnaround Time	-0.109 **	0.005	-0.143 **	0.033	-0.107 **	0.005	-0.179 **	0.056
Throughput	-0.658 **	0.256	-0.759	0.717	-0.273	0.242	-1.336 *	0.790
Distance					-0.216	0.218	0.30	0.58
Line haul cost for Tokyo	0.011 *	0.006	0.008	0.015				
Landing Fee for Tokyo	-0.019	0.089	-0.059	0.153	-0.020	0.072	-0.079	0.222
Turnaround Time for Tokyo	0.147 **	0.055	0.259	0.285	0.184 **	0.056	0.545	0.470
Distance for Tokyo					0.637	0.430	-0.474	1.223
No. Observations	760		760		760		760	
R-squared	0.46		0.41		0.44		0.28	
First stage F statistics	-		477.59 **		-		273.02 **	
J statistics (D.F.)	-		16.76 * (7)		-		15.15 (9)	

Note:

Dependent Variable = ln(s$_j$) - ln(s$_k$), where j and k are in the same pair of origin and destination.

The landing fee coefficients for Tokyo is multiplied by 1000 for presentation.

First-stage F statistics provide the average explanatory power of the instruments, conditional on the included exogenous variables

J statistics provides an overidentifying restriction test.

* Significance at the 95-percent confidence level.

** Significance at the 99-percent confidence level.