BOEING VS AIRBUS: AN EMPIRICAL EXAMINATION

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A thesis submitted in partial fulfillment of
the requirements for the degree of

Master of Arts in Economics

National University "Kyiv-Mohyla Academy"
Economics Education and Research Consortium
Master's Program in Economics

2005

Approved by ____
Ms.Svitlana Budagovska (Head of the State
Examination Committee)

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Program Authorized
to Offer Degree Master's Program in Economics, NaUKMA

Date ____

National University "Kyiv-Mohyla Academy"

Abstract

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This study considers the choice of an aircraft for different routes by airlines, in light of recent realization of different strategies of main players in aircraft production industry. Based on large sample of transatlantic flights from the US to European countries by different airlines, results show positive relation between probability of airlines choosing Airbus and average capacity of flights on that route, European origin of an airline and departures frequency; negative relation was found for the probability of choosing Airbus and distance of the route, destination country GDP per capita and, most interestingly, flights from/to hub airports and routes connecting two large airports. From the results of the study we conclude that development of new products by aircraft producing companies is based not on the future forecasts only but also on existing specifics of their products exploitation.

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ACKNOWLEDGMENTS

The author wishes to express his gratitude to his adviser, Dr. Volodymyr Bilotkach, for his support, insightful comments and invaluable contribution to this study by providing initial and main dataset. Special thanks are expressed to Dr. Tom Coupe and Dr. Polina Vlasenko for their kind attention to the study and useful comments during all the process of the thesis writing.

GLOSSARY

Hub. An airport used by an airline to route its passengers within its network.

Hub-and-spoke network. Network within which passengers are routed through a single or multiple hubs.

VLA. Very large aircraft.

Wide-body aircraft. Aircraft with two or more aisles across the cabin.

Narrow-body aircraft. Aircraft with one aisle across the cabin.

Open skies agreement. Agreement between countries that liberalizes air connection between them allowing airlines from those countries to perform flights in/from and within partner country.

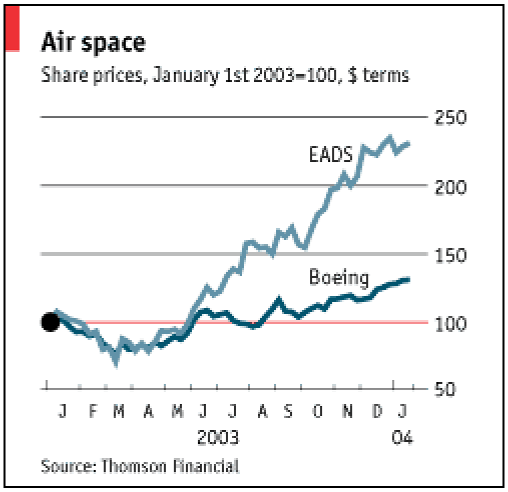
Chapter 1

INTRODUCTION

Many industries are close to duopolies with two firms serving almost the entire market with other participants having negligible trading and production volumes. The profound examples include UMC and Kyivstar on the Ukrainian mobile communications market; Microsoft and Apple Computers in operating systems industry, Intel and AMD in production of computer processors. The list can be continued. Another example of such situation is the large civil aircraft industry, most production in which is proposed by Boeing Commercial Aircrafts and Airbus Industrie. While Boeing also has a military division producing missiles, specialized jets, etc, the main focus of this paper will be on the civil part as both firms are presented in the segment.

It is worth noting that competition between the companies is not only limited to the usual market sphere, it is also strengthened by the fact that corporations are situated in different regions of the world, Boeing in the USA (production in Seattle, headquarters in Chicago) and Airbus in the EU (Toulouse, France), which are both competing for the world economic leader position. This fact implies a number of supporting programs for corporations, credits under special conditions, subsidies, etc. This leads to frequent court visits on the issues of "oversubsidizing" and free trade norms protection (first initiated by Airbus when having minor positions on the market and recently renewed by Boeing when it started losing its market positions). But, as usual, the final word for the success or failure for the company's product is to be said by the market. As can be seen from the Figure 1[1], currently European company is more appreciated if deciding on the basis of share price, which in many cases serve as a good estimator of the company prospects estimator. And here it comes to the main difference between the competitors. They have chosen different ways of developing their products on the basis of their vision of the development of the passenger air transportation market in the future. Airbus made a bet on the hub-and-spoke system while Boeing concentrated on fast direct flights, which many customers prefer to indirect routes through hubs. Subsequently, they developed quite different aircrafts. But the buyers for relatively large jets are not so widely presented so as to have completely different customers for both companies. There still is a choice for airlines to which strategy to stick to and which airplanes to use to best fit their choice.

Figure 1 EADS and Boeing share prices



Source: Thomson Financial

Recently both main market players presented their upper class jets. Boeing was first with the upper midsize 7E7 Dreamliner (787 now, still not built) in December 2004, followed by Airbus with giant super-jumbo A380 (already has a plane, but not for the delivery) in January 2005. The aircrafts clearly demonstrate the strategic choices of the producers; double-decker A380 can carry 555 passengers normally with maximum of incredible 840 for up to 15000 km, while Boeing proposes about 300 seats and less distant flights readiness (slightly more than 14000 km). The only plane by Americans being near A380 in size is old 747-400ER with 416 passengers normal capacity (max 568) and slightly more than 14000 km distance of flight, but it was launched more than ten years ago and

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[1] Graph from The Economist, Jan 22nd 2004

currently no substitute for it is expected. Boeing's aims are confirmed by presentation on February 15, 2005 of the new member of the 777 family – 777-200LR Worldliner with main advantage of extended range, now reaching almost 17500 km and giving possibility to connect virtually any two cities of the world by direct flight with 301 passengers and revenue cargo on board. Main characteristics of the companies' largest planes are given below.

Table 1: Jumbos compared. Sources: Airliners.net, Wikipedia.

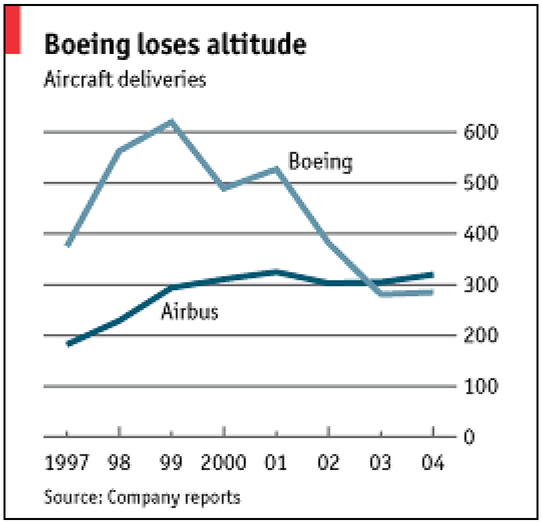
	Airbus A380-800	Boeing 747-400ER
Dimensions		
Length	72.8 m	70.7 m
Height	24.1 m	19.4 m
Wingspan	79.8 m	64.4 m
Wing area	845 m^2	541 m^2
Cabin width	6.58 m	6.10 m
Weights		
Operating empty	277,000 kg	181,755 kg
MTOW	540,000 kg	362,875 kg
Powerplants		
No. engines	4 turbofans	4 turbofans
Max engine thrust	374 kN (84,000 lb)	276 kN (62,000 lb)
Performance		
Cruising speed	902 km/h	907 km/h
Max speed	945 km/h	939 km/h
Range	14,800 km	14,205 km
Capacity		
Flightcrew	2	2
Seating (typical)	555	416 (23/78/315)
Seating (max)	840	568
Cargo	N/A	137-158.6 m^3

It is obvious that aims of the companies differ much; Airbus targets long-haul flights with hubs exploitation while Boeing is oriented on faster and more direct flights. Both choices have their pros and cons. For the first one positive distinction is possibility to have lower seat price due to lower in per seat terms fuel expenditures which in light of oil becoming more and more expensive is quite an important factor; second option has advantage in that most passengers prefer to enter the board in their departure airport and leave it in the destination place without having to waste time during additional stops in the hubs. From the other point of view, advantage of one is disadvantage for another; A380 development can be additionally slowed by the fact that many of the airports are currently technically not able to host it because of huge dimensions (mainly weight). But most of them already caught the idea and are planning modifications to meet the needs of the increased-size jets as they also suffer from the second line airports improved positions caused by low-cost carriers' expansion. As Eryl Smith, Heathrow's Director of business strategy, planning and development told the Press Association: "A380 is critical for us".

As was stated above, Boeing is not expected to present A380's direct competitor in the nearest future. Airbus, instead, already announced development of midsize A350 which is expected to be a direct competitor for the 7E7 (however, there was a rumor that such an announcement is nothing more than PR). Absence of competing aircraft from Boeing may be explained by extremely large costs associated with development of a jumbo. In this case, finally, Boeing's small and midsize aircraft will have to struggle with a bunch of direct competitors from Airbus and A380 having no counterpart from Americans. Taking into account the fact that in the industry usually some time is needed for an aircraft to be actually launched after it's official announcement (usually a few years, A380 will be delivered to first customers in 2007 and 7E7 will be in line in 2010), current actions and presentations can be seen as representing strategies for the nearest decade(s).

Considering financial backgrounds of the companies, main dynamics of improvement in Airbus' positions along with weakening of the Boeing's can be noted. While still a leader in profits, Boeing already lost first position in quantities[2] (talking about large civil jets segment, in 2001 the number of orders for Airbus jets exceeded number of orders for Boeing's jets). In the recent years Airbus collected more orders for their aircrafts but with high discounts and high development expenditures so that it did not allow them to become a financial leader. Now, main customers of the European company by orders are Lufthansa, Virgin Atlantic, Qantas, Malaysian Airlines, Emirates and Singapore Airlines. Other European airlines (beside Lufthansa) are also expected to order Airbus' planes. Boeing recently allowed Japanese firms to take close part in developing and producing 7E7 so as to create an additional incentive for the Japanese airlines to purchase jets in which production Japanese companies were involved. Talking about construction of the aircrafts we should note relative magnitude of constructing expenses, and here Airbus with its $12bln spent on A380 is ahead of American's expenses for Dreamliner.

Figure 2 EADS and Boeing aircraft deliveries


Boeing loses altitude
Aircraft deliveries

Source: Company reports

So, this is the situation. The question is whether expected preferences of the airlines are observed in reality. Our goal is to try to look at the same thing and derive our conclusion on whether managers' vision of the situation is in accordance with real data. Question will be addressed in a quite standard manner but using a rich dataset for the long period of time. In order to clarify the process of estimation and unify the data, analysis will be limited to transatlantic scheduled flights from the US. The rationale for such limitation of the sample is straightforward: Europe and America represent a larger part of the world's air

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[2] Graph from The Economist, Jan 20th 2005

travel market; most of the world's largest airlines are situated in the US and the EU; according to the data from Airports Council International, only 6 out of world's 30 busiest (as measured by the number of passengers arrived, departed and transited) airports were not in the US or the EU (others in Asia). Exclusion of charter flights is also logical as they do not represent regular or planned part of the traffic and cannot be viewed as the determining part in the airlines decisions on ways of flights development; also charter airlines have totally different business models from that of the scheduled airlines. We expect to achieve reliable results by using simple model with close attention paid to justification of variables' presence and functional form, which due to specifics of the data is probit regression. So, we will check whether vision of each of aircraft producing companies is in accordance with real data, for example is Airbus really used more for flights into/out from the hubs or whether probability of flight performed with Boeing increases with increase in distance of the flight.[3] Our findings [shows that there is positive relation between probability of Boeing aircraft exploitation on a route and distance of that route and level of well-being in the destination country (as measured by the GDP per capita), negative relation with average flight capacity on a route, frequency of departures and European origin of an airline. Unexpected result is that over the time period under consideration, hub flights and routes connecting large airports had positive effect on probability of Boeing exploitation.

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[3] Most of the facts in this chapter were taken from the various issues of The Economist magazine which author will be happy to provide (in electronic form) by the first request

Chapter 2

LITERATURE REVIEW

There is a number of papers considering airlines/aircraft industry. Interesting for the current research and also close in idea is paper by Esty and Ghemawat (2002). They concentrated on competition between the two main market participants in very large aircraft segment, where now only Airbus is presented with the new aircraft A380. Using game theory approach, decisions of the companies on products launch/cancellation were analysed on the basis of empirical data. The most striking finding was that it is possible to have potentially "more efficient" player losing the product launch competition, as it actually happened with very large aircrafts. As authors declared, two main questions to answer were why Airbus, not Boeing did launch the super-jumbo and why did Boeing's efforts to launch intermediate product (known as "stretch jumbo", being extended version of 747) falter? Nice and wide overview of the history of development of the VLA segment results in the conclusion that there were both similar opinions of the companies' management and differences. Common results of the considerations were that there are prerequisites for the growth of the market for jumbos and that the market for them will not be large enough to have room for more than one producer. Differences, as we also noted were in that estimates for the demand for VLA differed much across companies with Airbus predicting 3 to 4 times larger figure. This was the main point from which strategies of the companies departed in different destinations. Main factors included in the analysis were limited to operating profits, sales ramp-up, launch costs, funding sources, discount rates, terminal value, on-going expenditures and other variables consolidating currencies, inflation, tax rates. These limitations were done in order to make analysis more simple and tractable. As we can see authors' approach differs from our in that they concentrated on financial side and investment opportunities valuation while our approach will look at the demand for the VLA side mainly and airlines choices-influencing factors. Also their approach differs in methodology as they have used game theory framework for making inferences about producers' decisions. Research produced the conclusion that despite the fact that Boeing's potential benefits from launching larger jumbo were higher than Airbus' it was not enough. Lack of strategic arguments and possibility of temporary deterrence of the entry by using argument of cheap and efficient modification of the existing aircraft by Boeing allowed them to deter new product launch by competitors for some time and gain additional profits for some period (actually about one year) without making any investment, just by speculating with rumours and announcements. Also some insight on aircraft producers' decisions can be made by looking at the ideas presented by Benkard (2000). He considered learning effects in the aircraft production industry using data from Lockheed and found that there is evidence that aircraft production as a labour-intensive industry is subject to changing production costs and possibilities depending on the previous period's overall production levels and production of some particular types of aircraft in particular. He argues that in most cases there is a situation where new jets development influences not only costs beared by the firm directly but also affects other variable costs across the entire aircraft program. Hence, it is the case that large variety of different modifications with the one model in an unconstrained equilibrium is inefficient in that fewer modifications would allow producers to have lower cost both through direct and indirect effects. This can be tied to some Boeing's problems as American product line includes more different versions and modifications and also learning depreciation looks more likely to happen within Boeing than within Airbus.

Some descriptive ideas on Boeing and Airbus competition are presented in an article by Merluzeau (2004). Main differences in firms' development and market views are stressed. Among them is availability of strong governments' support for the Airbus, consequently, there is possibility to devote large funds to research and development activities so as to produce innovative products in short terms. As noted in the article, it took 20 years for Airbus to develop portfolio which was introduced by Boeing in 35 years. Once again, crucial differences in market views are also noticed and 20-year forecasts for VLA segment differ significantly with Europeans predicting more than 1600 VLA demanded during the period, while Boeing and Frost&Sullivan expect 536 and 750 VLAs demanded, respectively. Hub- and direct routes orientation is also taken into account. In general, article confirms previously given ideas and gives a short summary of the factors influencing aircraft producers' activities. Other paper considering Airbus-Boeing rivalry in general, and wide-body aircraft market segment competition in particular, is Irwin and Pavcnik (2004). For the reasons similar to ours they were interested in the demand specifics of the market for wide-body aircrafts. They estimated the demand function being dependent on technical characteristics like price, range, passengers seating, takeoff weight, and airline specific valuations and tastes. All available types of aircraft were divided into three broad categories: new wide-body aircraft (to which main attention is paid in the paper) and imperfect substitutes (called outside good) being represented by used wide-body aircraft and new narrow-body planes. Estimation was done using sample of data for 30 years from 1969 to 1998 for four main aircraft producers of that period (Airbus, Boeing, Lockheed and McDonnell Douglas). Estimated equation was nested logit $\ln S_j - \ln S_0 = x_j\beta + \alpha p_j + \sigma \ln S_{j|g} + \xi_j$, where S_j is observed market share (measured by quantity sold) of airplane *j*, S_0 is observed market share of outside good, $S_{j|g}$ is observed market share of aircraft *j* within its market segment *g*, x_j and p_j are vectors of product characteristics and prices, ξ_j represents airlines' tastes, additionally petroleum prices and GDP values were included. Use if IV methodology was justified by technical reasons. Results obtained showed possible positive dependency between market share and seats number and range, negative relationships between market share and aircraft's price and petroleum price was in line with expectations. Coefficients for other variables were insignificant. For the numerical results you are recommended to check the original work. Also interesting point was that empirical justification to the logical idea that higher degree of substitutability is present for the aircraft within one class than for interclass was adopted. Positive evolution of own-price elasticity showed that with time aircraft market becomes more sensitive to price changes. Cross-price elasticities were much smaller and different for the products of same segment and of different segments, latter being significantly larger. Additionally, close look is made on same particularly important for Airbus-Boeing competition events, such as 1992 US-EU aircraft pricing agreement and launch of Airbus A380, a direct competitor for Boeing 747 model and the largest super-jumbo in the industry. The 1992 subsidies-limiting agreement was found to result in increased prices but the magnitude of this increase could not be measured because of lack of necessary data. Simulation of A380 launch using announced (at that time) characteristics showed up the facts that are currently observed, namely, A380 undercutting smaller Airbus aircraft (A330 and A340) because of large discounts proposed to gain large market share for the new product right after presentation, along with lowering Boeing's market share. Overall effect was found to be positive for the European producer as their overall market share was expected to increase. Estimates for super-jumbos market capacity obtained in the paper are closer to those of Boeing but still accept the hypothesis that Airbus will be able at least to cover their development costs ($12 billion). In the analysis idea that A380 launch was more strategic than financial decision also appears, as producer's presence in all market segments can serve as additional reason for airlines to switch to their aircraft. Authors also support original Benkard idea that too wide variety of the models in the producers' line cause some problems as well because of cross-model demand effects of price discounts and problems with successful launch of new products without hurting own existing products. Counting for the industry specifics, like learning by doing principle and placing the industry into strategic sector, static analysis of the market may look inappropriate. However, for a long time dynamic approach was not used because of high computational difficulties. Recently Benkard (2000) tried to model the market from the dynamical equilibrium point of view and found it to be more applicable than previously used but still highly complicated. His model showed to be able to predict periodical lower than marginal costs pricing in the industry well and was treated as potentially perspective for future studies. However, his approach will not be used in this paper due to somewhat different data requirements and complexity which is well beyond the level of this paper.

From the other side, there is a number of papers looking at entry decisions of airlines concerning whole markets and specific routes. One of the most famous is Berry (1992). Using data from the *Origin and Destination Survey of Air Passengers Traffic* originally collected by the Civil Aeronautic Board, he looked at the entry and exit decisions of the airlines for the routes connecting 50 largest US cities. What was found is that firms take completely different actions in many cases, this was explained by the idea that besides the facts that are the same for the firms (like population, distances, tourism activities) there are factors which make firms heterogeneous and which affects their actions enough to make it reasonable to perform different actions for the same routes in the same period. One of these factors possibly could be differences in fleet used by the airlines, which question can be addressed later using some expected results from this paper. In paper by Boguslaski et al. (2004) entry patterns of one particular American low-cost carrier (LCC Southwest Airlines) were analysed. They found that expansion of the airline is going to continue. Taking into account that with time airline can become one of the most important participants in one of the world's biggest markets, and that this company almost does not explore hub routes, preferring direct flights, some additional positive argument in favour of the Boeing strategy can be added to the ones given before.

Yance (1972) postulated that airlines capacity is inflated by them until reaching the break-even level determined by the costs and demand conditions. This fact was explained by the idea that in such a way airlines try to secure themselves from having lower capacities than are demanded by the market. In this way, we can refer in our analysis to the idea that, by looking at the demand side of the market, estimates of the future demand for the aircrafts of different sizes can be achieved and, hence, potential gains for producers of different types of aircrafts can also be estimated. Later paper by Baltagi et al. (1998) contains new non-standard approach to the capacity issue. They used own-defined economic measures of capacity utilization instead of standard engineering load factor. Two capacity-utilization measures were calculated – demand-based measure and output-based measure. The former was defined as revenue passenger miles divided by capacity output and the latter as actual seat miles flown divided by capacity output. Capacity output was estimated as the minimum average cost output. The most interesting finding is that output-based capacity utilization coefficient of 1.0 (long-run equilibrium) corresponds to demand-based capacity utilization coefficient of 0.65, implying that physical excess capacity has little in common with economic one and, in essence, is quite a normal situation. This can be explained by specific features of demand for air travel, where same flights but in different time cannot be treated as perfect substitutes, common belief that overcrowded flights are associated with lower quality of service (more obvious for the case of restaurants, sporting events and cell phone communications). So, according to the results, presence of empty seats in the flights is potentially inevitable feature of the industry, thus increasing needed number of seats per flight well beyond what would be needed if looking at the demand level only.

Daniel (1995) proposes congestion pricing for the main hub airports in order to lower costs lost because of frequent delays caused by the fact that in many cases one time period is attractive for many flights so that airports' exploitation is divided unequally in time. Using pricing mechanism dependent not only on aircraft weight as it was before, but also congestion level at the arrival/departure time, would allow smoothing out the demand for aircrafts' presence in the airports hence decreasing congestion and saving delays-caused losses. Possible outcome of such decision would be moving of the origin/destination points to the secondary airports in order to keep attractive schedule without increasing costs; in which case additional limitations to the fleet type would possibly arise due to lower technical level of secondary airports. So, airlines' decision on fleet type can be highly influenced by exogenous factors implied by indirect for airlines reasons. Hendrics et al. (1995) approached the optimal structure of the airline network using mathematical methods to find that, with no variable costs and under assumption that passengers prefer less stops during the travel, hub-and-spoke network is optimal from the point of view of monopolistic company allowed to serve air connection between some number of cities. However, if variable costs are not restricted to be zero, another optimal solution arises, being the network with all cities connected directly. It is worth noticing that actually competing aircraft producers in this case also have different points of view on what optimum is observed by the airlines in that their recently presented products are oriented on one of the two network configurations provided in the paper. It is concluded that hubs network performs better with either high or low marginal costs but not with intermediate level.

Airlines competition development for the American market was considered in Borenstein (1992) and at that time it was found that despite the reasons that caused deregulation in late 1970s, at the beginning of 1990s, industry became heavily concentrated with possibility of needed regulation, ways out of the situation were described to be in opening the market for another non-American participants, improving access to the airports ground capacities and disclosure of commission rates by the travel agents. Mostly this things has happened in the time after paper was written, many open skies agreements were reached so that large European carriers are able to perform flights in the US (see APPENDIX A for the information on open skies agreements between the US and the European countries). What is important for our topic is that increased possibilities for foreign companies to act on the US air travel market to some extent justify our sample as only flights from the US are taken into analysis. Marin (1995) considered European airline market in view of prices and market structure and also found that success of deregulation, in sense of higher efficiency, highly depends on the equal availability of the airports facilities to market participants, which in the time of article appeared were highly controlled by the national flag carriers. Now, the situation is different, during recent years airports become more easily available to all market participants and this also is a good sign for our sample as such situation gives hope that it can be reasonable to make inferences on its basis. Similar results were also obtained by Evans and Kessides (1993) for their analysis of relation between dominance of an airline over an airport or over particular city-pair route. They revealed that dominance of an airline over an airport adds pricing power for that airline, while dominance over route does not give such possibility. They concluded that perspective way for public policy should be ensuring of equal access to the airports for different airlines in order to improve air transportation industry performance. Ideas much like that described are also present in Berry (1990) and Evans and Kessides (1994).

Golich (1992) looked at the problems arising from increased costs associated with R&D activities, treatment of the aircraft production industries as strategically important by governments and reached the conclusion that this sector should expect internationalization, but without specifying how in particular the process will be performed noting that development of an issue highly depends on the decisions of policymakers of the countries with aircraft producing firms. Actually, after the paper was written the situation developed by one of the scenarios described. Firms' evolution went so that currently two main players in the industry are present, being object of attention in this work. Also, EU authorities as well as US government see the industry as highly economically important with all the implications of such a position, like subsidies, cheap credits, other kinds of support and, of course, mutual court calls.

Chapter 3

DATA DESCRIPTION

As previously noted, this paper relies on extensive dataset. In particular, originally available data covered flights from the US airports to all the international destinations, both scheduled and charter, for the period 1990-mid-2002, monthly. These flights were described by number of passengers transported on a route, number of seats available and number of departures. As data was monthly, it does not represent each particular flight; rather activity of an airline on given route in given month was described. After checking the data we found that period 1990-1997 inclusively does not contain information on quantities of passengers transported for the flights performed by non-American airlines. This caused limitation of the sample to the time period 1998-mid-2002. Also we excluded charter flights and flights performed by cargo airlines, postal services, etc. But still main limitation was in using only data for transatlantic flights between US and Europe. This decision was made after considering the fraction of American and European long-haul flights market in overall long-haul flights market; another important reason is that we consider flights between the aircraft producing regions. These two markets present larger part of air transportation worldwide, this can be illustrated by the fact that most of the world's busiest airports are situated in these regions (for information on world's busiest airports as measured by the passenger traffic, see APPENDIX B). After applying these limitations, number of observations decreased to 11824 from initial 322019 (127522 for the time period included in the sample), including observations on flights from 36 American origin airports to 49 destination airports in 23 European countries, performed by 59 airlines, 12 of them American and 32 European with others from Asia and Africa (for the list of airlines and their origin, see APPENDIX C). This number of observations is still large enough to be representative for the general situation and not experience any problems with number of variables. Also, besides this dataset, we used data on orders and deliveries of Airbus and Boeing planes, data on Open Skies Agreements, destination country per capita GDP and international trade position, airport traffic. Finally, the set of variables included fourteen variables (six of them being dummy variables) and whole set (85) of dummies for destination airports. Namely, these are BOA, HUB, BWL, PM, PAX, DEPART, DIST, LF, ASEATS, OSA, TRADE, GDPPERCAPITA, NAMEUAL, EUAL and dummies for all airports, both origin and destination (for the complete list of airports and cities, both American and European, see APPENDIX D, later dummies for destination airports are called correspondingly to their code; for origin airports first letter "d" is added).

BOA (stands for Boeing Or Airbus) is a dummy variable having value of either 0 or 1 (it is later used as a dependent variable). It shows whether flights in a given month on a given route by a given airline were performed with Boeing (corresponds to value 0) or Airbus (corresponds to value 1) aircraft. Of all 11824 observations, 6474 (54.75%) are with zeroes, 5350 (45.25%) with unity. This shows that at the time period under consideration more airlines exploited Boeing aircraft for more routes. However, these values correspond to 364111 and 408893 departures respectively, indicating that on average each airline company on each route performed more flights per month with Airbus planes (approximately 76), than those using Boeings (approximately 56).[4] This variable was derived from the data on orders, deliveries and in-operation for Airbus and Boeing aircraft. For the airlines using both types of aircraft, distinction was made on the basis of the average number of seats per flight, as models of aircraft have

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[4] You can find frequencies and cross-tabs for dummy variables in APPENDIX F

different typical capacity. Some information on Airbus and Boeing aircrafts capacity and range can be found in APPENDIX E.

HUB is also a dummy which indicates whether origin or destination airport is considered as a hub (value 1) or not (value 0). This variable was created basing on the information which airports are used by particular airlines as hubs as suggested by the structure of the airline's network. For the American airlines it was composed so that hubs for AA are ORD, DFW, MIA ant STL; for CO hubs are EWR and IAH; for DL – ATL and CVG; for NW – DTW, MEM and MSP; for UA – ORD, DEN and SFO and for US – PHL, PIT and RDU. For the European airlines construction of the variable is straightforward (like BA and VS – LHR, LH – FRA, AF – CDG, etc.). 5477 (46.32%) of observations represent flights from/to the hubs.

BWL (stands for BetWeen Large) is one more dummy indicating if the route connects two large airports, which belong to the group of top 10 world's busiest airports (we compared data on world's largest airports for 2000-2002 and found that top 10 list remains almost constant, exception is SFO, which was in the list in 2000 but later changed by DEN). From our sample, 1515 (12.81%) of observations have value of unity for this variable, indicating route connecting two large airports; this corresponds to 15 routes, which represent nearly 16% of all the departures and passengers transported.

Two latter variables may seem highly related, but in fact they represent different effects. *HUB* corresponds to airline network specific factors, while *BWL* reflects that airports connected by the route are large. This factor may become especially important for A380 (because of huge weight of the aircraft) which will be launched in 2007; potentially there may be relation between the size of the airports and aircraft used for flights on a route during the time period under consideration.

PM (stands for Passenger Miles) is a variable formed by multiplying quantity of passengers transported on a given route by distance of that route. It is expected to reflect the scale of activity of an airline on a route. This number varies much and depends on how many flights an airline performs on a route and how large the distance between the origin and destination airports is[5].

PAX describes how many passengers were transported on a given route by an airline in each month when flights on that route happened. Like PM, it characterizes the level of airline activity on a route in a given month. It also varies much and depends largely on number of flights performed on a route. Also it is closely related to the load factor, together with number of seats determining average load factor for route by airline in each month.

DEPART is a variable which shows how frequently flights on a given route are scheduled by a given airline over a month. It varies from 4 to 493, showing that most frequent departures on a route were on average scheduled 16 times a day. Such frequent flights correspond to British Airways on a route New York (JFK) – London (LHR). Average number of the variable is 65, indicating that connection between two regions is quite intensive, as on average two departures per day are scheduled from the US airports for each route in each time period for each airline presented on a route.

DIST is variable describing distance between origin and destination cities. It was collected by myself using database on distance between large cities of the world. It does not pretend to be precise distance between airports as they are frequently situated in the suburbs, but few kilometers difference is relatively too small to play an important role in further results. Range of routes differs much being from 4676 km to 10200 km with the mean of 6893 km. Shorter routes are mostly

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[5] You can find descriptive statistics for non-dummy variables in APPENDIX G

presented by flights connecting USA eastern coast with UK, longer are from other regions to Germany and Eastern European countries.

LF (stands for Load Factor) is the variable created by dividing quantity of passengers actually transported by number of seats available. Obviously, its value falls between zero and unity. In this paper the load factor used is not the load factor for each departure. Due to specifics of the data, load factor shows average utilization of seats capacity for each route by each airline over a month. Value varies from miserable 5.6% to 100%. Mean of 75.6% is quite high and reflects possibility for further development of jet capacity or flights frequency. Relatively low standard deviation shows that large part of observations is near high mean.

ASEATS (stands for Average SEATS) was formed by dividing number of seats available on a route over month by number of departures on a route. This simply shows how large an aircraft is used by the airline. It should be noted that as we are interested in market for large aircraft, we excluded observations with value of this variable of less than 200. It represented quite a small part of all observations. Average number of seats for all flights connected with our sample is above 280, with maximum of 529. Standard deviation is not very large. This shows that for most flights popular models of aircraft were used. However, there are exceptions like Virgin Atlantic using only very large aircrafts with more than 350 seats. For this variable possible question may be why there are values with decimals. But this is explained by average character of the variable, counting that different aircrafts of the same model/producer can have slightly different number of seats, also we should count for possible insignificant mistakes in the number of seats offered over month values.

OSA (stands for Open Skies Agreement) is a dummy variable which indicates whether in particular month Open Skies Agreement between the USA and the destination country was present (value 1) or not (value 0). It takes value of unity for 5969 (50.48%) observations. Obviously, number of agreements increases over time and, consequently, fraction of unity values is higher than average in later months and lower than average for the starting periods.

TRADE is a variable which represent total international trade turnover of the destination country, measured as sum of exports and imports, quarterly. So, it shows trade turnover of the country over the quarter in which month of observation is. This data is collected from the International Financial Statistics directory published by the International Monetary Fund monthly and covering detailed data for several years before the publication. It was processed so as to transform it to some comparable units, by converting values into dollars using relevant exchange rates also available in the directory. Variable is usually considered as a relevant indicator of scale of country's participation in international economical and business relations and, hence, can be expected to show how much business travels are performed by the citizens of that country. Obviously, values vary much as different countries are present in the sample as destination points.

GDPPERCAPITA is a variable describing destination country's internal well-being, measured as GDP per capita in terms of constant 1995 US dollars, quarterly. Mean is USD 5198 (note that this a high value as data is quarterly and mean value corresponds to GDP per capita of USD 20808 if presenting annually) indicating that most of the air connection happens with countries with highly developed economies (we restricted the sample to US-Europe flights, but in Europe we included countries such as Poland, Romania, etc., for which GDP per capita is significantly lower than value mentioned above).

OAL (stands for Other AirLine) is a dummy variable, which indicates whether observation corresponds to the non-American and non-European airline (value

1) or not (value 0). Of the entire sample, 898 (7.59%) has value of unity for this variable.

EUAL (stands for EUropean AirLine) is also a dummy, indicating whether flights on a route were executed by European airline (value 1) or not (value 0). For 6830 (57.76%) observations this variable takes value of unity. Market share as measured by quantity of passengers transported or seats proposed does not differ much from frequencies for AMAL and EUAL variables showing similar load factors and departures frequencies for American and European carriers.

Two latter variable frequencies do not sum up to the total number of observations. Remaining observations corresponds to the flights performed by the American airlines; they represent 4096 (34.64%) observations. We should note that more activity in the market is undertaken by the European airlines. This can be explained by the fact that there are more airlines from Europe presented on the market. This, in turn, can be explained by the fact that they are mostly smaller than large American carriers; also there is still legacy of European market before the deregulation with each country having an airline (except Scandinavian countries with SAS), requirement for an airline to be from the country where the city is situated to be allowed to fly from that city to the US.

Other variables can be considered as a group as they are dummies for the destination airports (1 for flight to that airport, 0 otherwise), there are 85 of them. Four out of five most frequently visited airports in Europe are in top 10 busiest airports of the world, one is in top 30. These airports are LHR (1647, 13.93%, top 10), FRA (1503, 12.71%, top 10), AMS (1321, 11.17%, top 10), LGW (1247, 10.55%, top 30) and CDG (1121, 9.48%, top 10) and collectively represent 6839 (57.84%) observations. For the origin airports, two out of five most frequently used for transatlantic flights airports are in top 10 world's busiest airports and two in top 30. These are JFK (2149, 18.17%, top 30), EWR (1348, 11.40%, top

30), ORD (1263, 10.68%, top 10), LAX (793, 6.71%, top 10), IAD (762, 6.44%) and together represent 6315 (53.41%) observations. Comparing these we can note that it looks like airlines activities in Europe are more concentrated than in the US for the flights on US-Europe routes.

We should also note from the cross-tabs in APPENDIX F that value of unity for variable BOA (flights performed with Airbus jets) is more common together with unity for HUB and BWL, than value of zero (flights with Boeings). This gives us a sign of high possibility that hypothesis of positive correlation between Airbuses exploitation and hub flights is actually observed. From the same appendix we can find that presence of Open Skies Agreement is positively connected with activity of European airlines on the market, as should be expected.

Chapter 4

METHODOLOGY

Theoretical background

As you may note from the data description section, our dependent variable is a dummy, or an indicator variable. This limits choice of tools that can be used for an estimation procedure. Reasons of limitations and possible approaches to estimation will be shortly described below; more attention will be paid to the method used in this paper, namely probit. Most of the theoretical information in this chapter was taken from Greene "Econometric Analysis". Interested readers should refer to that book, but any other literature considering estimation with discrete dependent variable will work as well. Here we will limit our attention to the models for binary choice as they are directly connected with this paper's method.

When it comes to the estimation of the models with discrete dependent variable (binary choice in our case), exploitation of the simple techniques like OLS is not suitable anymore. Reason for this lies in the very nature of such a model. Problem is that with use of regression approach, estimating model $\overline{y} = F(\overline{x}, \overline{\beta}) = \overline{\beta' x} + \overline{\varepsilon}$, residual term ε is inevitably heteroscedastic in a way that depends on the coefficients in the regression. As $\beta' x + \varepsilon$ must be equal to either 0 or 1, residual term ε equals either $-\overline{\beta' x}$ or $1 - \overline{\beta' x}$ with probability $1 - F$ and F respectively (where F is a function that shows the probability of dependent variable taking value of unity). Further it is easy to show that in such a case $Var\left[\overline{\varepsilon} \middle| \overline{x}\right] = \overline{\beta' x}(1 - \overline{\beta' x})$. Next, and more troublesome, shortcoming is that resulting coefficients combined with variables values cannot be restricted to the

$[0,1]$ interval, thus producing meaningless probabilities and negative variances. Requirement for the model is to produce coefficients such that following properties would be observed (in general case): $\lim_{\beta'x \to \infty} \Pr(Y=1)=1,\ \lim_{\beta'x \to -\infty} \Pr(Y=1)=0$ for a given regressor vector. So, models that rely on different distributions appeared. First one is based on the assumption of normal distribution which is $\Pr(Y=1)=\int_{-\infty}^{\beta'x}\phi(t)dt=\Phi(\overline{\beta'x})$, where last notation is commonly used for the standard normal distribution, this model is referred to as a probit model. Another version uses logistic distribution which is presented as $\Pr(Y=1)=\frac{e^{\beta'x}}{1+e^{\beta'x}}=\Lambda(\overline{\beta'x})$, with last notation being commonly used for the logistic cumulative distribution function, this model is called logit model. Two distributions are quite similar, but logistic has significantly heavier tails, so that both distributions give similar probabilities to the intermediate values, but different for large or small values, this difference can be easily seen from the Figure 3. Different outcomes from these models should be expected if: 1) there is large inequality in the distribution of binary variable and 2) very large variation in an important independent variable, especially if 1) is also present. Resulting probability model is a regression $E\left[y\,|\,\overline{x}\right]=0\left[1-F(\overline{\beta'x})\right]+1\left[F(\overline{\beta'x})\right]=F(\overline{\beta'x})$,

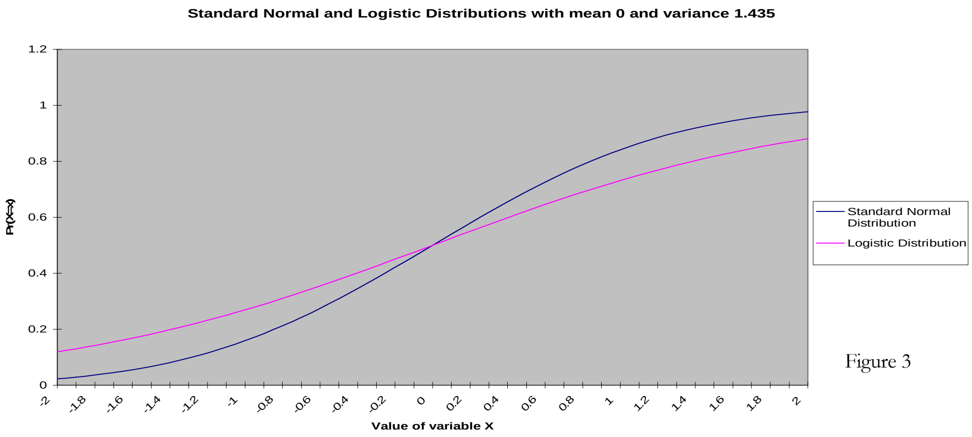

Figure 3

where $F(\cdot)$ is either standard normal or logistic distribution. Immediate result from such specification is that parameters no longer represent usual marginal effects directly. Now if we want to see how the dependent variable would change in response to change in the regressor, we need to find the value of the following derivative: $\frac{\partial E\left[y|\bar{x}\right]}{\partial \bar{x}} = \left\{\frac{dF(\bar{\beta}'\bar{x})}{d(\bar{\beta}'\bar{x})}\right\}\beta = f(\bar{\beta}'\bar{x})\beta$ where $f(\cdot)$ is the density function corresponding to the cumulative distribution, $F(\cdot)$. For the normal distribution assumed in probit models, this results in $\frac{\partial E\left[y|\bar{x}\right]}{\partial \bar{x}} = \phi(\bar{\beta}'\bar{x})\beta$, where $\phi(t)$ is normal standard density; for the logistic distribution assumed in logit models, we have $\frac{\partial \Lambda\left[\bar{\beta}'\bar{x}\right]}{\partial \bar{\beta}'\bar{x}} = \frac{e^{\beta' x}}{(1+e^{\beta' x})^2} = \Lambda(\bar{\beta}'\bar{x})\left[1-\Lambda(\bar{\beta}'\bar{x})\right]$ and the result is $\frac{\partial E\left[y|\bar{x}\right]}{\partial \bar{x}} = \Lambda(\bar{\beta}'\bar{x})\left[1-\Lambda(\bar{\beta}'\bar{x})\right]\beta$. Obviously, values of these derivatives depend on values of the variable and vary with them. They are mostly computed for the mean values of the variable, other method is to calculate for each observation and then get average of those marginal effects, for the large sample this methods should give similar results. Computing marginal effects for some particular values of the regressors is also convenient. Following figure illustrates graphically the above description. On the graph it is easy to see the

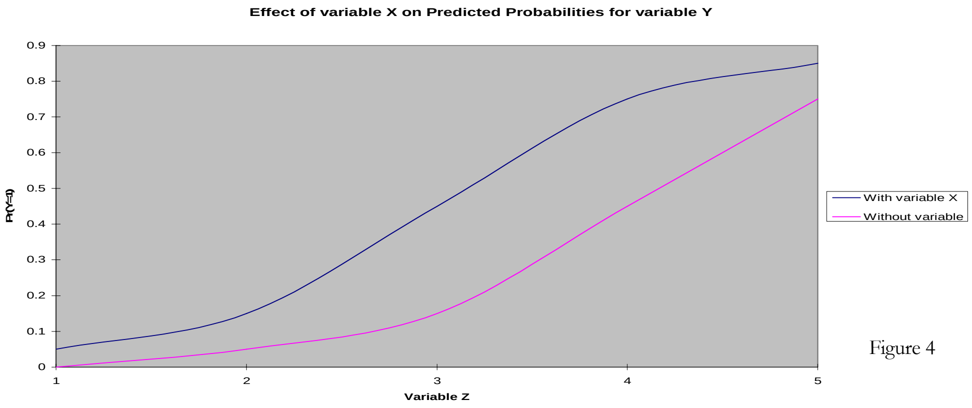

Figure 4

difference between the coefficients from the model and corresponding marginal effects. Horizontal difference between two curves is equal to the value of the estimated coefficient for the variable X, while vertical distance between the curves is marginal effect of the variable X on the probability of dependent variable being equal to unity. Easy to see that marginal effect of the variable X varies with changes in value of variable Z.

Estimation of the models is based on the method of maximum likelihood. Other notes related to the probit and logit models are that it is not recommended to exclude constant term from the estimation process unless this measure is justified by the technical necessity (elimination of the collinearity, etc.). It is also desired to have balanced dependent variable, e.g. with comparable number of observations with value of zero and value of unity.

Model specification

As it was previously noted in this paper we will use relatively simple technique, but it is quite appropriate for our data and purpose, so there is no need to complicate things artificially. We will estimate probit model. For our large sample with relatively balanced dependent variable (55% of observations have value of zero and 45% has value of unity), even if we would use logit, it should give similar results. So, the particular specification is:

$$
\begin{aligned}
&BOA = \beta_0 + \beta_1 ASEATS + \beta_2 OAL + \beta_3 EUAL + \beta_4 HUB + \beta_5 BWL + \\
&+ \beta_6 TRADE + \beta_7 GDPPERCAPITA + \beta_8 PAX + \beta_9 PM + \beta_{10} DEPART + \\
&+ \beta_{11} DIST + \beta_{12} DIST\hat{}2 + \beta_{13} LF + \beta_{14} OSA + \sum_{i=15}^{61} \beta_i AIRPORTDUMMY_i
\end{aligned}
$$

Note that we will include only 46 airport dummies in the model; this will be explained later in the estimation results section. Model is specified so as to catch possible influence from all the factors influencing decision on which aircraft to use.

Remaining part of this chapter deals with the expected coefficients and reasons for the expectations. These expectations are based on the information described in the introduction, mainly beliefs about how and for which routes aircrafts of two producers are used. So, main difference is that Airbuses are seen to be used for flights in hub networks; consequently flights are shorter and quantity of passengers transported per flight and in general on the route should be large. Also, because of shorter flights, frequency should also be high and price lower because of specifics of the hub networks. Boeings are seen as better for direct flights connecting two end-points of the travel, hence less frequent, with smaller capacity and more expensive. From these assumptions, the expected coefficients are as follows.

Technical factors are presented by the *DIST* (distance between origin and destination cities), *DEPART* (number of departures on a given route by a given carrier monthly), *ASEATS* (average number of seats offered for flights on a route for an airline monthly), *LF* (average load factor for flights by an airline on a route monthly) and *PAX* (total quantity of passengers transported on a route by an airline during a month) variables. They are expected to influence decision in a way that limits choice to some particular models of aircraft that are better from one or other aircraft producer (more suitable capacity, cruising speed, takeoff weight, required frequency of service can be better for particular airline in one of the producers aircraft). *DIST* should have negative effect on the probability of exploitation of Airbus aircraft; this is a straightforward result from the assumptions above. We expect to have coefficients with positive signs for *ASEATS*, *PAX* and *DEPART* variables. For the *LF* we do not have strong expectations but this factor is believed to have influence on aircraft choice.

TRADE (international trade turnover, measured as imports and exports in USD in a destination country quarterly) and *GDPPERCAPITA* (per capita GDP in a destination country quarterly) are expected to represent requirements of the main customers for the air travel, showing up scale of business activity (and business travels) and customers' ability to pay respectively. These variables stand for the part of business travel and ability to pay for the travel and should be positively correlated with what is seen as Boeings' specific – fast, direct and relatively expensive flights (as should be true if decision on new products by aircraft producers is made based on the available information for the previous products).

HUB (shows whether origin or destination airport is a hub for an airline that performs flights on a route) and *BWL* (shows whether route connect two airports from top 10 world's largest airports or not) represent specifics of the flights and airports that are connected by that flight. Expected sign for the HUB coefficient is also directly driven by the assumptions, it should be positive. Coefficient for the *BWL* variable should be positive as larger airports are associated with larger scale of passenger transportation on a route and can possibly be used as hubs by smaller airlines, not performing transatlantic flights but transporting passengers from the large airports to the end-points of their travel.

Finally, *PM* (passengers transported over month on a route by an airline times distance of the route), *EUAL* (shows whether observation is for the European airline or not) and *OAL* (shows whether observation corresponds to activity of non-American and non-European airline or not) represent regional specifics of the airlines. First one is seen as representing airlines' scale of activity and is expected to have negative coefficient as large airlines are considered as more conservative ones and move slowly to the new products (Airbus is new comparing with Boeing). An expected coefficient of the latter variable is positive. This is straightforward taking into account that Boeing is an American company, while Airbus origin is Europe and that aircraft production is treated as a strategic sector of the economy in both regions. There is a belief that American airlines prefer Boeings other things being equal, while European ones favour Airbus. For the *OAL* variable coefficient we do not have strong expectations, it is included in order to allow us to see effect of an airline being from Europe influence the probability of choice of an Airbus, comparing to the airlines from the US. Constant term is preserved as it is not recommended to drop it for type of model used here; a few control variables will be dropped to avoid collinearity (more on this in the results section). For the *OSA* variable (indicates presence of Open Skies Agreement between the US and the destination country) we would expect positive coefficient if we would consider later period (Airbus gained much in sales quantities on discounts, but this taken place after the time period considered here). The reason is that the variable reflects the idea that the presence of Open Skies Agreement tightens competition in the industry. Stronger competition leads to higher attention to the problems of cost minimization and, hence, intensive search for aircraft purchases under better terms. At that time period and previous years (it takes some time to deliver an aircraft after an order), however, Boeing was a leader in both quantities sold and revenues (from this we conclude that Boeing offered better terms of purchases), so for this model we expect negative coefficient of the variable. We believe that the factors named above collectively determine which aircraft an airline would use for which route and, consequently, purchases of that aircraft by the airline.

In the process of estimation, problem of possible inverse causality between variables was considered; also we paid close attention to the clear and correct determination of the variables. In the beginning *HUB* variable was specified simply as large airport but after taking into account the fact that flights to some large airport (CDG for example) are actually hub flights for some companies (AF continuing with the example), but not so for other (BA, DL, LH, etc.). So, the variable was reformulated to avoid this problem. Inverse causality is also not expected to be present as actually decision on which aircraft to use is made with other conditions (origin and destination, distance, expected capacity of the route, type of travels on that route) being predetermined.

After obtaining coefficients from the model we will look at the marginal effects of the variables. Of particular interest are marginal effects for the *HUB, BWL*, *OAL* and *EUAL* variables. This will give possibility to say whether positive relation between hub flights and Airbuses exploitation are observed in our sample and whether preferences for aircraft produced in their regions are observed for the airlines from the US and Europe or are just beliefs of the companies' management. Also, it is interesting to see what is the direction and magnitude of the effect of route connecting large airports.

Chapter 5

RESULTS

Estimation Results

Before proceeding to the results of the estimation, let us shortly remind the idea behind the model and main points that were checked. We look at the decisions of the airlines on which aircraft to use for flights in relation with different factors that should influence such decision. Our goal is too see what factors influence the decision and in what manner. Main interest is in the marginal effects, which show how presence of some factor influence the decision in favour of one of the available aircraft types.

Below is the table with coefficient values for all the variables except control variables and statistics on them (full estimation output can be found in APPENDIX H). These results do not give final result but shows the direction in which influence is observed.

Table 2. Coefficients from the probit model estimation

Variable	Coefficient	p-value	Variable	Coefficient	p-value
ASEATS	0.000828	0.038	*PM*	0.0021131	0.146
HUB	-0.6736826	0.000	*PAX*	-0.0000339	0.008
OAL	-0.309162	0.000	*DEPART*	0.0085643	0.000
EUAL	0.568899	0.000	*DIST*	-0.0015451	0.000
BWL	-0.9978611	0.000	$DIST^2$	0.000000175	0.000
TRADE	0.00000467	0.051	*LF*	0.3686423	0.028
GDPPC	-0.0004418	0.000	*OSA*	0.167449	0.082

From the table we can note that not all the coefficients are statistically significant, also some of the estimated coefficients' signs are not in accordance with expectations. The model fits the data well as is indicated by relatively high value of the R^2 parameter which equals 0.4536. Important note is that before the estimation we excluded a number of control variables as many of them have not exhibited variation with the dependent variable (i.e. flights to Helsinki were performed by Finnair Oy only and using Boeings only – hence no variation between the regressand and the dummy for HEL is observed; similar case is with some other destination and origin airports), a few were excluded in order to avoid collinearity. As main interest for us lies in the marginal effects of the variables, we will describe the coefficients just briefly. Most of them are significant at 5% level of significance, hence affect the dependent variable. *ASEATS, GDPPERCAPITA*, *EUAL*, *DEPART* and *DIST* have expected signs. Positive values of the *ASEATS*, *EUAL*, and *DEPART* variables' coefficients reflect positive influence of this factors presence/increase on probability of choosing Airbus. For the *GDPPERCAPITA* and *DIST* the effect is negative, thus reflecting the negative effect of these factors on probability of choosing Airbus. *HUB*, *BWL* and *PAX* variables have coefficients that differ from the expected. These coefficients show negative for Airbus influence on aircraft choice. *LF* has positive coefficient's sign, for *OAL* the sign of the coefficient is negative. *TRADE*, *PM* and *OSA* coefficients were found to be statistically insignificant. As we previously noted main interest of this paper is represented by *OAL*, *EUAL*, *HUB* and *BWL* variables.

Final step in estimation is to obtain the marginal effects of the regressors on the dependent variable. As stated in the methodology section, the most common way is to estimate marginal effect of the regressor with other independent variables taken at their mean values. However, for our case this approach is not the best one as we have dummies among the regressors and it is better to look at the marginal effects for different values the dummies and their combinations.

Marginal Effects

We will start by examining the most interesting for us variables and their effect on the choice of an aircraft. Below is a table with marginal effects for the *HUB* (flights reformed through hub airport correspond to unity value) and *BWL* (flights connecting two airports from the top 10 world's largest airports correspond to unity value) variables. We examined them for different values of other main variables, all variables for which values are not mentioned are taken at the mean values (except the cases when their values are obvious, like if *EUAL*=1, then *OAL*=0 by construction of these dummies).

Table 3. Marginal Effects of *HUB* and *BWL* variables

BWL (p-values in parentheses)		*HUB* (p-values in parentheses)	
OAL=1, *HUB*=0	-0.0966374 (0.019)	*EUAL*=1, *BWL*=0	-0.2101182 (0.000)
EUAL=1, *HUB*=0	-0.2742276 (0.000)	*EUAL*=1, *BWL*=1	-0.0671938 (0.028)
EUAL=1, *HUB*=1	-0.1313032 (0.006)		
OAL=0, *EUAL*=0, *HUB*=0	-0.1513567 (0.003)	*OAL*=0, *EUAL*=0, *BWL*=0	-0.1233843 (0.002)
OAL=0, *EUAL*=0, *HUB*=1	-0.050793 (0.045)	*OAL*=0, *EUAL*=0, *BWL*=1	-0.0228207 (0.098)

Most of the estimated marginal effects are significant at 5% level of significance; insignificant is marginal effect of *HUB* for the case of American airlines' flights between large airports. Obviously, effects of the variables are negative. Of interest here is magnitude of the effects and results for the different combinations of other variables' values. For the *BWL* variable the effect is negative but differs much depending on other variables. Larger values correspond to flights performed by the European airlines from/to non-hub airports, while lower correspond to the airlines from other regions flights and flights from hubs. Interesting feature is that *BWL* has the largest negative influence if combined with non-hub flights performed by the European airlines. For the *HUB* variable, effects pattern is similar. Larger negative values correspond to flights performed by the European airlines. Actually these negative values give us possibility to reject the idea that in the past choice of Airbus for the flights was favored by the fact that the route is from/to hub airport or connects two large airports. Instead, we observe an inverse relation – these factors increased probability of choosing of Boeing aircraft for the flights. Despite the fact that these results sound counterintuitive based on our assumptions, they are still easily explained. We should note that in the time-period under consideration Boeing was undoubtedly in the leading position and most of the large airlines used Boeing aircraft for their flights, especially if looking at the aircraft with large capacity (e.g. more that 350 seats, until the presentation of A380 Airbus jets' capacity didn't exceed 380 seats in standard configuration). Hence, the results reflect Boeing's leading position in the large airlines sector during the time period under consideration.

Next are the marginal effects for the *OAL* (flights performed by non-American and non-European airlines) and *EUAL* (flights performed by an airline from Europe) variables. They are constructed in the similar way - we examine cases of different values for main variables while others are taken at their mean values).

Table 4. Marginal Effects of *OAL* and *EUAL* variables

OAL		*EUAL*	
EUAL=0, *HUB*=0, *BWL*=0	-0.0693311 (0.004)	*OAL*=0, *HUB*=1, *BWL*=0	0.0973134 (0.003)
		OAL=0, *HUB*=1, *BWL*=1	0.0168032 (0.110)
EUAL=0, *HUB*=0, *BWL*=1	-0.0146119 (0.096)	*OAL*=0, *HUB*=0, *BWL*=0	0.1840473 (0.000)
		OAL=0, *HUB*=0, *BWL*=1	0.0611764 (0.025)

We can see that the marginal effects of airlines origin indicators are positive for European airlines and negative for non-American and non-European airlines; some of them are statistically insignificant as indicated by high p-values. We should note that these effects are comparing to the American airlines. So we can conclude that airlines being from Europe favor Airbus more comparing to those from the US, while airlines from other regions prefer Boeing, comparing to American and European airlines. This is actually in line with our expectations where we expected to observe European airlines preference for Airbuses if compared with their American counterparts. Other important issue is that hub routes decrease probability of Airbus exploitation; route connecting two large airports also decrease probability of Airbus exploitation. General conclusion from the table above is that we can accept the hypothesis stating that European airlines exhibit preference to the European aircraft.

The following table presents marginal effects for *DIST* (distance between the origin and destination cities) and *GDPPERCAPITA* (per capita GDP for the destination country) variables. They are examined separately for airlines from different regions; all other variables are taken at their mean values. Note that for the *DIST* variable estimation of marginal effect is not straightforward, as we included squared distance in our estimation to allow for non-linear effect of distance. This variable has very small but positive coefficient. Hence, for marginal effects of distance we estimate marginal effects of both *DIST* and $DIST^2$ variables and then look at the overall effect resulting from 1 km change in distance from the mean value (6893 km). This way seem much wiser than estimating only marginal effect for *DIST* without counting that it is to some extent outweighed by the effect of $DIST^2$. Also the effect of the change in distance differs depending on from what distance the change happens, with larger (in absolute value) effects corresponding to smaller distances and larger (in absolute value) effects corresponding to larger distances. But as we noted in the data description chapter and as can be seen from the APPENDIX G, standard deviation of the DIST variable is not very large (1113), hence we suppose that estimating of marginal effect at the mean value is reliable and values of the effect are applicable for most of the observations. All the marginal effects for *DIST* and *GDPPERCAPITA* variables are statistically significant at 5% level of significance.

Table 5. Marginal Effects of *DIST* and *GDPPERCAPITA*

DIST (modified)		*GDPPERCAPITA*	
OAL=1, *EUAL*=0	-0.000129448 (0.005)	*OAL*=1, *EUAL*=0	-0.0000438 (0.026)
OAL=0, *EUAL*=1	-0.000380786 (0.000)	*OAL*=0, *EUAL*=1	-0.0001290 (0.000)
OAL=0, *EUAL*=0	-0.00020651 (0.000)	*OAL*=0, *EUAL*=0	-0.0000700 (0.005)

We can see that both variables affect the probability of Airbus choice in a way that we have expected, for both variables the effect is negative. The effect is larger (in absolute value) for the airlines from Europe and the lowest (in absolute value) corresponds to airlines not from the US or Europe. Effects are negative and show that increase in route distance by 100 km results in 1.29% to 3.81% lower probability of choice of Airbus for that route. Increase of USD1000 in the destination country's per capita GDP per year results in 1.1% to 3.23% lower probability of choice of Airbus for the route. These results are completely in correspondence with our expectations and show that Boeings were preferred for long routes with larger fraction of relatively rich passengers, that are able to pay more for faster and direct flights.

Last pair of variables for which marginal effects are estimated is *ASEATS* (average number of seats offered per flight on a route by an airline during a month) and *DEPART* (number of departures on a route by an airline during a month). They are estimated in a simple manner, without any complications, separately for airlines from different regions, with all other variables taken at their mean values.

Table 6. Marginal Effects of *ASEATS* and *DEPART* variables

ASEATS		*DEPART*	
OAL=1, *EUAL*=0	0.0000821 (0.138)	*OAL*=1, *EUAL*=0	0.0008495 (0.041)
OAL=0, *EUAL*=1	0.0002417 (0.062)	*OAL*=0, *EUAL*=1	0.0025001 (0.000)
OAL=0, *EUAL*=0	0.0001311 (0.108)	*OAL*=0, *EUAL*=0	0.0013565 (0.011)

As expected, values are positive and show us that increase in average capacity of the flight on a route by 100 seats corresponds with 0.82% to 2.42% higher probability of choice of an Airbus for that route. The effect is very small but it support hypothesis that Airbuses were used for flights with higher capacity on average. Exceptions are flights were aircraft with very large capacity were used as at that time period Airbus could not propose jets with more than 400 seats, but flights with such a high capacities usually connect large airports and we remember that marginal effect of the BWL variable was significantly negative. This simple explanation allows to understand effect of ASEATS variable better in that they corresponds to usual capacity values, not extremely large ones. Marginal effects for the DEPART variable show that increase in number of departures on a route over month by 10 corresponds with 0.85% to 2.5% higher probability of choice of an Airbus for that route. Smaller effects correspond to flights of non-American and non-European carriers, while larger are for airlines from Europe.

Results allow us to accept most of the hypotheses posed in the beginning of the paper. Based on the findings, we support the idea that Airbus aircrafts were used for frequent flights with higher capacity and that European airlines exhibit preference for the jets of the European producer; while Boeings were more likely used for long, direct and relatively expensive flights. However, we can contradict one of the main hypotheses, that Airbuses were preferred for hub flights. We found strong negative effect of hub routes, as well as routes connecting two large airports, on a probability of an Airbus being chosen for flights on those routes.

Chapter 6

CONCLUSIONS

This study investigates the factors determining the decision of airlines on which aircraft, Boeing or Airbus to use for different flights. We examined rich dataset covering transatlantic flights by different carriers from the US to the European countries for the recent time period, to find out main relations between the airlines choices and different characteristics of the route for which the choice is made and an airline itself. Among the main factors considered are distance, passengers' ability to pay, type of airports connected, average capacity of the flights on a route and others.

We found that factors such as average capacity on a route, European origin of an airline and departures frequency are positively related to the probability of choosing Airbus for flights on that route; factors such as distance and destination country GDP per capita are negatively related to probability of choosing Airbus for flights on that route. The most interesting result is that negative relation between hub flights and probability of choosing Airbus for those flights was established; same relation was found for the flights connecting two large airports. General conclusion is such that when deciding on future products, aircraft producers account for existing relations and their actions are based on future market forecast, as well as existing specifics of their products exploitation. So, decision by Airbus to develop large aircraft is based, beside large estimated capacity of the market for very large aircraft, on the facts that previously their products were more likely used for relatively shorter flights with high capacity; while Boeing executives decided on new extra-long-range aircraft development taking into account that Boeing aircraft is preferred for relatively distant direct flights with relatively low capacity. Unexpected negative relation between hub flights and probability of choosing Airbus is explained by the idea that for hub flights mostly aircraft with high capacity is used and over the previous period Boeing produced larger jets that had no competitors from Airbus.

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APPENDIX A

History of Open Skies Agreements between USA and European countries[6]

#	Date	Entity	Remarks	Total # of OSA
1	January 2002	France	Open Skies Agreement	55
2	May 2001	Poland	Open Skies Agreement	53
3	October 2000	Malta	Open Skies Agreement	50
4	January 2000	Slovak Republic	Open Skies Agreement	41
5	December 1999	Portugal	Open Skies Agreement	40
6	November 1998	Italy	Open Skies Agreement	32
7	December 1997	Romania	Open Skies Agreement	27
8	February 1996	Germany	Open Skies Agreement	12
9	December 1995	Czech Republic	Open Skies Agreement	11
10	May 1995	Austria	Open Skies Agreement	10
11	May 1995	Belgium	Open Skies Agreement	9
12	May 1995	Denmark	Open Skies Agreement	8
13	May 1995	Finland	Open Skies Agreement	7
14	May 1995	Iceland	Open Skies Agreement	6
15	May 1995	Luxembourg	Open Skies Agreement	5
16	May 1995	Norway	Open Skies Agreement	4
17	May 1995	Sweden	Open Skies Agreement	3
18	May 1995	Switzerland	Open Skies Agreement	2
19	February 1992	Netherlands	Open Skies Agreement	1

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[6] Data from U.S. Department of Transportation

APPENDIX B

World's busiest airports, 2002[7]

Rank	City (Airport)	Total passengers
1	Atlanta (ATL)	76876128
2	Chicago (ORD)	66565952
3	London (LHR)	63338641
4	Tokyo (HND)	61079478
5	Los Angeles (LAX)	56223843
6	Dallas/Ft Worth Airport (DFW)	52828573
7	Frankfurt/Main (FRA)	48450257
8	Paris (CDG)	48350172
9	Amsterdam (AMS)	40736009
10	Denver (DEN)	35651098
11	Phoenix (PHX)	35547167
12	Las Vegas (LAS)	35009011
13	Madrid (MAD)	33913456
14	Houston (IAH)	33905253
15	Hong Kong (HKG)	33882463
16	Minneapolis/St Paul (MSP)	32628331
17	Detroit (DTW)	32477694
18	Bangkok (BKK)	32182980
19	San Francisco (SFO)	31456422
20	Miami (MIA)	30060241
21	New York (JFK)	29943084
22	London (LGW)	29628423
23	Newark (EWR)	29202654
24	Singapore (SIN)	28979344
25	Tokyo (NRT)	28883606
26	Beijing (PEK)	27159665
27	Seattle (SEA)	26690843
28	Orlando (MCO)	26653672
29	Toronto (YYZ)	25930363
30	St Louis (STL)	25626114

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[7] Data from Airports Council International

APPENDIX C

List of airlines

Code	Airline	Country
6F	Laker Airways	USA
AA	American Airlines	USA
AF	Air France	France
AI	Air India	India
AY	Finnair Oy	Finland
AZ	Alitalia	Italy
BA	British Airways	UK
BD	Bradley	UK
BG	Biman Bangladesh	Bangladesh
CO	Continental	USA
CYQ	Corse Air	France
DE	Condor Flugdienst	Germany
DL	Delta Air Lines	USA
EI	Aer Lingus	Ireland
ET	Ethiopian Airlines	Ethiopia
FF	Tower Air	USA
H2	City Bird	USA
HY	Uzbekistan Airways	Uzbekistan
IB	Iberia Air Lines	Spain
IJ	Interjet	USA
IW	Aom Minerve	France
JK	Spanair	Spain
KL	KLM Royal	Netherlands
KM	Air Malta	Malta
KU	Kuwait Airways	Kuwait
LG	Luxair	Luxembourg
LH	Lufthansa	Germany
LO	LOT	Poland
LT	Luftransport	Germany
LX	Translux	Switzerland
LY	El Al Israel Airlines	Israel
LZ	Bulgarian Airlines	Bulgaria
MA	Malev	Hungary
MP	Martinair Holland	Netherlands
NG	Lauda Air	Italy
NW	Northwest Airlines	USA
NZ	Air New Zealand	New Zealand
OA	Olympic Airways	Greece
OK	Czech Airlines	Czech Rep.
OS	Austrian Airlines	Austria
PE	Air Europe	Italy
PK	Pakistan Airlines	Pakistan
PR	Philippine Airlines	Philippines
RJ	Alia-Royal Jordanian	Jordanian
RO	Tarom Romanian	Romania
SK	Scandinavian Airlines	Denmark
SN	Sabena World Air	Belgium
SQ	Singapore Airlines	Singapore
SR	Swissair Transport	Switzerland
SU	Aeroflot	Russia
SV	Saudi Arabian Airlines	Saudi Arabia
TN	Air Tahiti Nui	Tahiti
TP	TAP Airlines	Portugal
TW	Trans World Airlines	USA
TZ	American Trans Air	USA
UA	United Air Lines	USA
US	USAir	USA
UX	Air Europa	Spain
VS	Virgin Atlantic	UK

APPENDIX D

List of airports and cities

Airport	City, Country/State	Airport	City, Country
AGP	Malaga, Spain	LUX	Luxembourg, Luxembourg
AMS	Amsterdam, Netherlands	MAD	Madrid, Spain
ANC	Anchorage, Alaska, USA	MAN	Manchester, England, UK
ARN	Stockholm, Sweden	MCO	Orlando, Florida, USA
ATH	Athens, Greece	MEM	Memphis, Tennessee, USA
ATL	Atlanta, Georgia, USA	MIA	Miami, Florida, USA
BCN	Barcelona, Spain	MLN	Melilla, Spain
BGR	Bangor, Maine, USA	MSP	Minneapolis/St Paul, Minnesota, USA
BHX	Birmingham, UK	MSY	New Orleans, Louisiana, USA
BOS	Boston, Massachusetts, USA	MUC	Munich, Germany
BRU	Brussels, Belgium	MXP	Milan, Italy
BSL	Basel, Switzerland	NCE	Nice, France
BUD	Budapest, Hungary	OAK	Oakland, California, USA
BWI	Baltimore, Maryland, USA	OPO	Oporto, Portugal
CDG	Paris, France	ORD	Chicago, Illinois, USA
CLT	Charlotte, North Carolina, USA	ORY	Paris, France
CPH	Copenhagen, Denmark	OSL	Oslo, Norway
CVG	Cincinnati, Ohio, USA	OTP	Bucharest-Otopeni, Romania
DEN	Denver, Colorado, USA	PHL	Philadelphia, Pennsylvania, USA
DFW	Dallas/Ft Worth, Texas, USA	PHX	Phoenix, Arizona, USA
DTW	Detroit, Michigan, USA	PIT	Pittsburgh, Pennsylvania, USA
DUB	Dublin, Republic of Ireland	PRG	Prague, Czech Republic
DUS	Düsseldorf, Germany	RDU	Raleigh/Durham, North Carolina, USA
EWR	Newark, New Jersey, USA	RSW	Ft Myers, Florida, USA
FAI	Fairbanks, Alaska, USA	SAN	San Diego, California, USA
FCO	Rome, Italy	SEA	Seattle, Washington, USA
FLL	Ft Lauderdale, Florida, USA	SFO	San Francisco, California, USA
FRA	Frankfurt, Germany	SLC	Salt Lake City, Utah, USA
GLA	Glasgow, Scotland, UK	SNN	Shannon, Republic of Ireland
GVA	Geneva, Switzerland	SOF	Sofia, Bulgaria
HAM	Hamburg, Germany	STL	St Louis, Missouri, USA
HEL	Helsinki, Finland	STN	London, England, UK
IAD	Washington, D.C., USA	STR	Stuttgart, Germany
IAH	Houston, Texas, USA	SUJ	Satu Mare, Romania
IEV	Kiev, Ukraine	TPA	Tampa, Florida, USA
JFK	New York, New York, USA	TRF	Sandefjord, Norway
KBP	Kiev, Ukraine	TSR	Timisoara, Romania
KRK	Krakow, Poland	TXL	Berlin, Germany
LAS	Las Vegas, Nevada, USA	VCE	Venice, Italy
LAX	Los Angeles, California, USA	VIE	Vienna, Austria
LGW	London, England, UK	WAW	Warsaw, Poland
LHR	London, England, UK	ZRH	Zurich, Switzerland
LIS	Lisbon, Portugal		

APPENDIX E

Airbus and Boeing aircraft capacity and range

Airbus		**Boeing**	
A300-600		***747-400***	
Capacity, seats	266	Capacity, seats	416/524
Range, km	7700	Range, km	13450
A310		***747-400ER***	
Capacity, seats	220	Capacity, seats	416/524
Range, km	9600	Range, km	14205
A330-200		***757-300***	
Capacity, seats	253	Capacity, seats	243/280
Range, km	12500	Range, km	6287
A330-300		***757-200***	
Capacity, seats	295/335	Capacity, seats	200/228
Range, km	10500	Range, km	7222
A330-300E		***767-400ER***	
Capacity, seats	295	Capacity, seats	245/304/375
Range, km	13700	Range, km	10454
A340-600		***777-300***	
Capacity, seats	380	Capacity, seats	368/451/550
Range, km	14640	Range, km	11029

APPENDIX F

Descriptive statistics for dummy variables (*BOA*, *HUB*, *INTERHUB*, *OSA*, *OAL*, *EUAL*, *AMAL* and some airport dummies)

```
. tab boa

        BOA |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |      6,474       54.75       54.75
          1 |      5,350       45.25      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab hub

        Hub |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |      6,347       53.68       53.68
          1 |      5,477       46.32      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab bwl

        BWL |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,309       87.19       87.19
          1 |      1,515       12.81      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab osa

        OSA |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |      5,855       49.52       49.52
          1 |      5,969       50.48      100.00
------------+-----------------------------------
      Total |     11,824      100.00
```

```
. tab oal

    NAMEUAL |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,926       92.41       92.41
          1 |        898        7.59      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab amal

       AMAL |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |      7,728       65.36       65.36
          1 |      4,096       34.64      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab eual

       EUAL |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |      4,994       42.24       42.24
          1 |      6,830       57.76      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab boa amal

           |         AMAL
       BOA |         0          1 |     Total
-----------+----------------------+----------
         0 |     4,108      2,366 |     6,474
         1 |     3,620      1,730 |     5,350
-----------+----------------------+----------
     Total |     7,728      4,096 |    11,824

. tab boa eual

           |         EUAL
       BOA |         0          1 |     Total
-----------+----------------------+----------
         0 |     2,916      3,558 |     6,474
         1 |     2,078      3,272 |     5,350
-----------+----------------------+----------
     Total |     4,994      6,830 |    11,824
```

```
. tab boa hub

           |          Hub
       BOA |         0          1 |     Total
-----------+----------------------+----------
         0 |     3,886      2,588 |     6,474
         1 |     2,461      2,889 |     5,350
-----------+----------------------+----------
     Total |     6,347      5,477 |    11,824

. tab boa bwl

           |          BWL
       BOA |         0          1 |     Total
-----------+----------------------+----------
         0 |     5,838        636 |     6,474
         1 |     4,471        879 |     5,350
-----------+----------------------+----------
     Total |    10,309      1,515 |    11,824

. tab osa amal

           |         AMAL
       OSA |         0          1 |     Total
-----------+----------------------+----------
         0 |     3,631      2,224 |     5,855
         1 |     4,097      1,872 |     5,969
-----------+----------------------+----------
     Total |     7,728      4,096 |    11,824

. tab osa eual

           |         EUAL
       OSA |         0          1 |     Total
-----------+----------------------+----------
         0 |     2,658      3,197 |     5,855
         1 |     2,336      3,633 |     5,969
-----------+----------------------+----------
     Total |     4,994      6,830 |    11,824

. tab lhr

        LHR |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,177       86.07       86.07
          1 |      1,647       13.93      100.00
------------+-----------------------------------
      Total |     11,824      100.00
```

```
. tab fra

        FRA |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,321       87.29       87.29
          1 |      1,503       12.71      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab ams

        AMS |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,503       88.83       88.83
          1 |      1,321       11.17      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab lgw

        LGW |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,577       89.45       89.45
          1 |      1,247       10.55      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab cdg

        CDG |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,703       90.52       90.52
          1 |      1,121        9.48      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab djfk

       DJFK |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |      9,675       81.83       81.83
          1 |      2,149       18.17      100.00
------------+-----------------------------------
      Total |     11,824      100.00
```

```
. tab dewr

       DEWR |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,476       88.60       88.60
          1 |      1,348       11.40      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab dord

       DORD |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     10,561       89.32       89.32
          1 |      1,263       10.68      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab dlax

       DLAX |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     11,031       93.29       93.29
          1 |        793        6.71      100.00
------------+-----------------------------------
      Total |     11,824      100.00

. tab diad

       DIAD |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     11,062       93.56       93.56
          1 |        762        6.44      100.00
------------+-----------------------------------
      Total |     11,824      100.00
```

APPENDIX G

Descriptive statistics for non-dummy variables (*PM*, *PAX*, *DEPART*, *DIST*, *LF*, *ASEATS*, *TRADE*, *GDPPERCAPITA*)

```
. sum pm pax depart dist lf aseats trade gdppercapita

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
          pm |     11824    9.65e+07    7.30e+07     510300   5.72e+08
         pax |     11824    14157.66    10800.67         84     102504
      depart |     11824    65.37585    46.14984          4        493
        dist |     11824    6893.756    1113.916       4676      10200
          lf |     11824    .7559337    .1294296   .0566572          1
-------------+--------------------------------------------------------
      aseats |     11824    281.2301    67.26051        200      529.4
       trade |     11824    1.34e+11    7.40e+10   2.02e+09   2.74e+11
gdppercapita |     11824    5198.309    1304.873        306      10924
```

APPENDIX H

Estimation results

```
Probit estimates                                  Number of obs   =      11824
                                                  LR chi2(60)     =    7387.25
                                                  Prob > chi2     =     0.0000
Log likelihood = -4448.6444                       Pseudo R2       =     0.4536

------------------------------------------------------------------------------
         boa |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      aseats |    .000828   .0003981     2.08   0.038     .0000478    .0016081
         hub |  -.6736826   .0512388   -13.15   0.000    -.7741088   -.5732565
        eual |    .568899   .0407781    13.95   0.000     .4889755    .6488226
         oal |   -.309162   .0734798    -4.21   0.000    -.4531797   -.1651443
         bwl |  -.9978611   .0880123   -11.34   0.000    -1.170362   -.8253602
       trade |   4.67e-06   2.39e-06     1.95   0.051    -1.49e-08    9.35e-06
gdppercapita |  -.0004418   .0000495    -8.92   0.000    -.0005388   -.0003448
          pm |   .0021131   .0014536     1.45   0.146     -.000736    .0049621
         pax |  -.0000339   .0000128    -2.65   0.008     -.000059   -8.81e-06
      depart |   .0085643   .0014422     5.94   0.000     .0057377    .0113909
        dist |  -.0015451   .0004326    -3.57   0.000     -.002393   -.0006972
       dist2 |   1.75e-07   2.31e-08     7.58   0.000     1.30e-07    2.20e-07
          lf |   .3686423   .1674807     2.20   0.028     .0403861    .6968984
         osa |    .167449   .0963351     1.74   0.082    -.0213643    .3562622
         ams |    11.0267   2.534416     4.35   0.000     6.059339    15.99407
         arn |   8.886224    2.58162     3.44   0.001     3.826343    13.94611
         ath |   8.232472   3.020837     2.73   0.006     2.311739     14.1532
         bcn |   11.54235   2.605777     4.43   0.000     6.435122    16.64958
         bhx |   11.91666   2.453574     4.86   0.000     7.107742    16.72557
         bru |   7.647386   2.543849     3.01   0.003     2.661533    12.63324
         cdg |   12.44738   2.550738     4.88   0.000     7.448025    17.44673
         dub |   13.28785   2.341131     5.68   0.000     8.699319    17.87638
         fco |   10.35723   2.789458     3.71   0.000     4.889992    15.82447
         fra |    11.6405   2.685451     4.33   0.000     6.377115    16.90389
         gla |    11.5696     2.3923     4.84   0.000     6.880782    16.25842
         lgw |   11.28362   2.487287     4.54   0.000     6.408623    16.15861
         lhr |   11.72426   2.486698     4.71   0.000     6.850425     16.5981
         lis |   12.49746   2.445742     5.11   0.000     7.703896    17.29103
         mad |   10.73255   2.482399     4.32   0.000     5.867138    15.59796
         man |   12.02762   2.424528     4.96   0.000     7.275632    16.77961
         muc |    8.58321   2.748077     3.12   0.002     3.197079    13.96934
         mxp |   10.39372   2.683739     3.87   0.000     5.133692    15.65376
         ory |   9.808126   2.560393     3.83   0.000     4.789848     14.8264
         snn |   13.51679   2.291149     5.90   0.000     9.026219    18.00736
         vie |   11.82864   2.755311     4.29   0.000     6.428331    17.22895
         zrh |   9.580911    2.64742     3.62   0.000     4.392063    14.76976
        datl |    3.70527   .3587046    10.33   0.000     3.002222    4.408318
        dbos |   6.079515   .7037654     8.64   0.000      4.70016     7.45887
        dbwi |   3.700078   .6132427     6.03   0.000     2.498144    4.902011
        dclt |   3.529399   .4601889     7.67   0.000     2.627445    4.431353
        dcvg |   3.302608   .4714397     7.01   0.000     2.378603    4.226613
        dden |    3.60778   .2917913    12.36   0.000      3.03588    4.179681
```

```
        ddfw |   6.626177   .3267133    20.28   0.000     5.985831    7.266524
        ddtw |   4.772989   .5155882     9.26   0.000     3.762455    5.783523
        dewr |   4.752872   .6216507     7.65   0.000     3.534458    5.971285
        diad |   5.623337   .5440431    10.34   0.000     4.557032    6.689642
        diah |   2.077614   .2663064     7.80   0.000     1.555663    2.599565
        djfk |   4.783861   .6223743     7.69   0.000      3.56403    6.003692
        dlas |   1.067988   .3425024     3.12   0.002     .3966953     1.73928
        dlax |   2.245747    .401482     5.59   0.000     1.458857    3.032637
        dmco |   3.479855   .3247934    10.71   0.000     2.843271    4.116438
        dmem |   2.463279   .4891785     5.04   0.000     1.504507    3.422051
        dmia |   4.168569    .302396    13.79   0.000     3.575884    4.761255
        dmsp |   4.128614   .4488858     9.20   0.000     3.248814    5.008414
        dord |   6.319589   .4422777    14.29   0.000     5.452741    7.186437
        dphl |   5.284593   .5961719     8.86   0.000     4.116118    6.453069
        dphx |   .7946199   .3759992     2.11   0.035      .057675    1.531565
        dpit |    4.32292   .5387339     8.02   0.000     3.267021    5.378819
        dsea |   3.665931   .2782983    13.17   0.000     3.120476    4.211385
        dsfo |   2.516873    .363122     6.93   0.000     1.805167    3.228579
       _cons |  -12.44144          .        .       .            .           .
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