Air travel choices in multi-airport markets

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Abstract

We study how air travel consumers departing from a multi-airport region trade-off across airport and airline supply characteristics. We empirically investigate this trade-off by estimating a weighted conditional logit model of airport-airline choice, using survey data on travels departing from one of three San Francisco Bay area airports and arriving at one of four airports in greater Los Angeles in October 1995. Non-price characteristics like airport access time, airport delay, flight frequency, the availability of particular airport-airline combinations, and early arrival times are found to strongly affect choice probabilities. Marginal effects and counterfactual scenarios are calculated to compare the values of these characteristics among each other and across traveler type. In order to examine the robustness of the conditional logit model, we estimate a mixed logit model, and find that the results are similar. We attribute the similarity to our strictly defined travel market and to our distinction between leisure and business travelers, thus controlling for two important sources of consumer heterogeneity. We consider the implications of our empirical findings on vertical integration between airlines and airports and on the competitive effect of entry by low cost carriers.

Keywords: airports, airlines, air travel demand, discrete choice

JEL codes: L11, L15, L93, R410

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1. Introduction

Many studies of competition in the airline industry define markets for air travel in terms of airport pairs. While justified in markets where both the trip origin and the destination are served by a single airport, this approach is less suitable for markets characterized by a high density of demand, where travelers often have a choice of airport at both the travel origin and destination. Large metropolitan areas (for example Boston, Chicago, Los Angeles, New York, San Francisco, Washington D.C.) typically are served by several nearby airports that provide flights to common destinations. However, the exact set of choices available at a metropolitan airport will differ as airlines do not provide the same set of flights at each airport. Furthermore, the frequency, nature (direct versus connecting), and price of flights to a destination offered by an airline will vary across competing airports. This often forces air travelers departing from or arriving at a multi-airport area to trade-off across airline and airport characteristics.

Consider a traveler departing from San Jose, California in 1995. The traveler has access to three airports: nearby San Jose Airport (SJC), San Francisco Airport (SFO), and Oakland Airport (OAK). United Airlines' frequent flyer rewards arguably are more valuable than those of other airlines, as it offers the most service out of the Bay Area and, for many destinations, has the greatest frequency of flights. United Airlines, however, does not operate out of nearby San Jose. Southwest Airlines does operate out of San Jose and offers a lower fare than United. Thus, the traveler faces a trade-off between the bundle {more valuable frequent flyer program, greater flight frequency} and the bundle {lower airport access time, lower fare}. The actual choice is likely to depend on the traveler's trip purpose. In case of a business trip, fares may matter less, while leisure travel may be less responsive to frequent flyer rewards.

This paper empirically studies such trade-offs by examining the air travel choices of travelers departing from the Bay Area to the greater Los Angeles area in October 1995. We treat each traveler's air travel options as products that are differentiated by airline and airport characteristics. We specify a large set of such characteristics, allowing us to investigate the underlying motives supporting a given traveler's airline and airport choice, and identify separately the factors that affect the choice for a particular airline from those that influence airport choice. Moreover, the survey data at the heart of our study allows us to examine how different types of travelers – by location in the Bay Area and trip type (business or leisure) – value these factors.

We use a combination of datasets to estimate weighted conditional logit and mixed logit models. We find that preferences are not strongly lexicographic across airline and airport characteristics; travelers do not simply choose the lowest fare, closest airport, or most desirable airline (i.e. frequent flyer program). Many characteristics are influential, but there are limits to how much a traveler is willing to sacrifice in other characteristics. This suggests that existing studies of airline competition that define markets as simply airport pairs ignore important airport substitution effects in multi-airport regions, leading to biased estimates of traveler preferences for airline characteristics.

As our model estimates the valuation of specific airport and airline characteristics, we can decompose the airport substitution effect, allowing us to consider hypothetical alternative bundles of airport and airline offerings. For example, since Southwest Airlines often enters the secondary airport in a multi-airport area, rather than the main hub airport, current estimates of the competitive influence of Southwest on incumbent, legacy airlines are conditional on the degree of airport substitutability. These estimates may be misleading when analyzing the effect of Southwest entering the hub airport. We explore this issue using counterfactual simulations based on our estimated models of airport and airline choice. One such scenario indicates that Southwest Airlines would lose market share if it moves out of Oakland and into San Francisco (where it was not present in 1995), at least when United Airlines matches the Southwest fares. The reason is that United Airlines is a strong competitor in San Francisco, because of the high frequency of service that it offers. Consequently, Southwest's choice to focus on Oakland may be driven in part by a desire to avoid direct competition with United Airlines, in San Francisco airport.

Insight into the separate role of airport and airline characteristics may also be helpful when analyzing the effects of further vertical separation between airlines and airports. Airports seek increased independence from airlines, partly because it has become riskier to rely on one or a few airlines revenues (FAA/OST, 1999). But when there are no strong vertical ties, airlines can move out of an airport relatively easy, especially when nearby substitute airports exist. In such a context, airports need to consider how their market share depends on airport characteristics, but also on airline characteristics. Our estimates and the counterfactual scenarios indicate that both are of crucial importance.

The paper is structured as follows. Section 2 reviews related literature and describes our contributions to it. Section 3 describes the data and the results of the weighted conditional logit and mixed logit models; we present coefficient estimates and marginal effects. Section 4 discusses counterfactual scenarios that illustrate the joint impact of the estimated model. Section 5 summarizes and concludes.

2. Literature

Our empirical analysis is related to a relatively small literature on airport choice in a multi-airport region, where the choice for an airport may be modeled as such, or in combination with transport mode choices for ground access or with airline choices.[1] The models are estimated using discrete choice techniques of varying complexity and generality, but there is wide consensus that ground access times and quality of service (often measured by flight frequencies) strongly affect the choice for a particular airport. We review some contributions that, like us, use the 1995 air traveler survey for the Bay Area airports as the central source of data on travel choices.

Pels et al. (2001) analyze the choice for an airport and an airline in the San Francisco Bay Area using a nested logit model, and find that a model where the airport is chosen first and the airline next is statistically preferred over the reverse choice structure. Using the same dataset and a nested logit model to look at the choice of access mode and airport, Pels et al. (2003) find that the mode choice patterns imply high values of time. Basar and Bhat (2002, 2004) estimate a probabilistic choice set multinomial logit model of airport choice by business travelers residing in the Bay Area. Their model allows the choice set to be constructed by travelers, in particular allowing for the possibility that travelers do not take all departure airports into account. They find that access time matters, more so than frequency, but that the effect of access time is weaker and that of flight frequency is stronger than in a standard multinomial logit model, where the choice set is exogenously given. Most recently, Hess and Polak (2004) analyze airport choice in the San Francisco Bay Area using a mixed multinomial logit specification, so allowing for

[1] The early contributions are by Skinner (1976), Harvey (1987) and Ashford and Bencheman (1987).

random preference variation, and find that this affects the results. One suggested explanation as to why a mixed logit model performs better than the standard logit model, is that not all variation in the sensitivity of airport choice to access time is captured by observed traveler characteristics.

Our analysis starts by defining a specific market for air travel, and this leads to three main differences with the reviewed work. First, we restrict attention to a specific set of destinations (four airports in or around Los Angeles), rather than lumping all destinations together as is done in the above mentioned studies. In doing so, we delineate a specific market in which carriers compete directly. The particular market is served by direct flights, so that aspects of network competition (other than hub dominance, which we take to be exogenous to the market under study) are relatively unimportant. Also, unobserved variation in egress times from destination airports is lower after controlling for arrival airports. Second, we consider a more detailed representation of flight characteristics and flight choice than earlier studies. For example, we consider differences between business and leisure travel, between peak and offpeak travel, and between early and late flights. We use information on fares and on delays at arrival and departure airports, and we allow for airline specific effects. Finally, we correct for choice based sampling, specifically for over-sampling of travelers departing from San Jose airport, in order to obtain an estimated model that is suitable for marginal effects calculation and counterfactual simulation. Many, but not all, previous studies have relied on the result in Manski and Lerman (1977) that, for a conditional logit model, the bias from choice-based sampling is limited to estimates of the choice-specific intercepts, not the slope coefficient estimates.[2] However, marginal effect calculations and counterfactual simulations, which are of interest in this paper, depend on all coefficient estimates, including the intercepts.

While our analysis focuses on airport and airline choice, we think of it as being informative to analyses of competition in the air transportation industry. Some studies of airline competition explicitly recognize the importance of airport characteristics. In particular, researchers have focused on the impact of “airport dominance” and airport congestion on airline competition. Key papers on the role of airport dominance in airline

[2] This result does not necessarily hold for other discrete choice models

competition include Borenstein (1989, 1991), Berry (1990, 1992), Morrison and Winston (1989), Evans and Kessides (1993), and Berry, Carnall and Spiller (2006).[3] A central idea here is that larger airport presence increases the value to consumers of frequent flyer programs and other airline marketing programs, and this enables airlines to charge higher fares. However, the ability of airlines to use airport dominance to extract consumer surplus will depend on the presence of substitute airports: in markets served by multiple airports, the dominance of any one airport by an airline does not necessarily preclude other airlines from offering a similar array of flights. This type of effect is discussed in Morrison (2001), who finds that the presence of Southwest at nearby airports disciplines carriers at any particular airport, but the effect is weaker compared to the case where Southwest competes in the same airport. Borenstein (2005, table 2) provides suggestive evidence that airport competition may reduce the impact of airport dominance on airfare, in that hub airports in metropolitan areas served by multiple airports (e.g. San Francisco Bay Area, Los Angeles, Chicago, New York, D.C.) seem to be associated with lower hub premiums than hub airports in single airport markets (e.g. Charlotte, Cincinnati, Detroit, Memphis Minneapolis).[4]

A different strand of the air transportation literature studies service quality competition, with an emphasis on on-time performance, and starting from the basic observation that flights into or out of certain airports are prone to travel delay more than others. Apart from natural causes (e.g. fog at San Francisco), airport congestion can contribute to travel delay, with hub airports particularly congested as airlines seek to

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[3] Of particular relevance is the Morrison and Winston (1989) study which uses an empirical strategy similar to ours. They estimate the impact of airport presence on airline choice by applying a multinomial logit model to DB1A passenger data. Our study can be considered an extension of theirs – expanding the choice set to include airport choice. Our data also provide more information about the passengers than DB1A.

[4] Airport choice has implications for the empirical literature on airline entry, where increased attention has been brought to the issue of low-cost carriers, most notably Southwest, entering the markets of incumbent, hub-and-spoke carriers. Recent research includes Ito and Lee (2004) and Goolsbee and Syverson (2005). If city airports are imperfect substitutes, they are a form of product differentiation for the airline. Given that low cost carriers often enter the adjacent, non-hub airport in major metropolitan areas, current studies may underestimate the change in market share and incumbent response effected by the entry of a low cost carrier at the hub airport. One of our counterfactual exercises addresses these issues.

maximize economics of traffic density (scope). This is demonstrated in Brueckner and Spiller (1994) and Mayer and Sinai (2003). Mazzeo (2003) finds that on-time performance is worse (delays are more common and longer) on concentrated routes, suggesting that airlines may use airport dominance to extract surplus not only through higher airfares but also through cost savings associated with the offering of lower quality service. Here too, however, the availability of substitute airports may provide an incentive for dominating airlines to offer higher quality service. In this context, Januszewski (2004) estimates the value that travelers attach to on-time performance. Using an exogenous shock to the on-time arrival of flights to LaGuardia, she finds that longer delays imply lower prices, and that the size of the effect depends on the availability of substitutes: when substitute flights are available at the same or at competing airports, changes in service quality have larger effects on prices.[5] Flights at the same airport are closer substitutes, and therefore have a larger effect. In addition, the effects are larger for business travelers, presumably because they strongly dislike schedule delays.

We build upon these earlier works that consider the impact of airport characteristics on airline competition by adopting an explicit choice-based framework that allows us to model demand for a flight from a given airport as responding not only to characteristics of that airport but also of competing airports. In a multi-airport market, a traveler who wishes to avoid paying the fare premium at a "dominated" airport or the travel delay at a congested airport does not necessarily have to avoid flying. She can choose to fly out of a competing airport, factoring in any sacrifices she must make, such as longer airport access time or flying with a less preferred airline. A choice-based framework allows us to estimate the effect of airport dominance and travel delay while explicitly controlling for the airline offerings and observable airport characteristics at competing airports. Thus, our estimates of the demand-side impacts of airport dominance and travel delay better incorporate the trade-offs travelers face in a multi-airport market.

[5] The overall effect is estimated at $1.16 per minute of delay, increasing to $1.55 when there is competition.

3. Estimating an airport and airline choice model for air travel from the San Francisco Bay Area to greater Los Angeles in 1995

3.1 Data and basic specification

Our data describe the choice set, the actual choices, and the main time and money costs associated with the choice alternatives, for travelers traveling by air from the San Francisco Bay Area to greater Los Angeles during two weeks of October 1995. Specifically, we observe the choice of departure airport, arrival airport, carrier, peak or offpeak departure, and early or late flight.[6] The time cost components associated with each possible choice include the driving time from the initial origin to the airport, the expected flight delays at the departure airport and at the arrival airport, and the schedule delay cost as approximated by the frequency of flights per airline per airport and controls for early and late departures.[7] The money cost is an approximation of the flight fare: because of data limitations, fares are measured at a much more aggregated level than other flight characteristics, and may be different from actual transaction prices. Our use of fare information is largely restricted to comparing average differences across flight choices; precise estimation of trade-offs between time and money (i.e. estimating values of time) is not possible. Lastly, we have information on a set of socio-demographic variables, including whether travelers travel for business or leisure purposes, the exact location of departure in the Bay Area, whether travelers are residents of or visitors to the Bay Area, and the travelers' income group.

The dataset is composed from various sources, the primary of which is the Airline Passenger Survey as conducted in August and October 1995 by the Metropolitan Transportation Commission (MTC) in collaboration with SFO, SJC, OAK, and Sonoma County Airport (STS).[8] The survey contains a purposely large number of interviews

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[6] Peak hours are from 6-9 am and 3-6 pm; all other hours offpeak. Early flights at an L.A. airport are those arriving within a time interval defined by the earliest arriving flight at that airport, plus 30 minutes. Late flights are those arriving at an airport in a time interval defined by the latest arriving flight, minus 30 minutes.

[7] We do not include flight times. Since all passengers fly to greater LA, the variation in flight times can be expected to be minimal.

[8] http://www.mtc.dst.ca.us/datamart/airpass1.htm. A first wave of the survey took place in August 1995 and a

conducted at SJC, but travelers were randomly interviewed at each airport. We correct for choice based sampling at the level of the airport in the estimation. After omitting observations because no fare is reported for the flight or no match could be made with the flight schedule data, because non-car access, or because no income was reported, 1,752 observations remain, of which 935 are business travelers and 817 are leisure travelers.

The airline passenger survey is combined with several secondary sources. First, the 1998 car travel times from a passenger's initial origin in the Bay Area to the airports are derived from the MTC's transportation network model.[9] Second, the summary of the Origin and Destination Survey (DB1A) as provided by Severin Borenstein provides aggregate fare data, as well as weights that correct for choice based sampling.[10] Third, Airline Online Performance Data from the Bureau of Transport Statistics provide information on delays at the level of the origin and destination airports.[11] Fourth, the Worldwide Through Flight Schedules Database obtained from OAG is used to construct passengers' choice sets. We assume that the complete set of flights was actually available to passengers at the time they purchased a ticket.

We first estimate a weighted conditional logit model defined over travel choices that are a combination of departure airport, arrival airport, airline, and peak or off-peak travel. The choices are conditional on the travelers accessing the airport of choice by car and flying to greater Los Angeles.[12] An example of a particular choice alternative is a flight from SFO to LAX with UA during peak hours; a different option would be a flight

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second one in October 1995. The August survey reports zero passengers departing from OAK using United Airlines (UA), which contrasts with other sources (OAG and T-100) that indicate a substantial presence of UA at OAK in August of 1995. Since our analysis considers airport and airline choice, it seemed appropriate to exclude the August data.

[9] ftp://ftp.abag.ca.gov/pub/mtc/planning/forecast/RVAL98/

[10] The weights obtained from DB1A were validated against T-100 data. T-100 is an alias for the 'Air Carrier Statistics Databank', based on 'Form 41 Traffic' collected by the BTS. T-100 data are segment based, but since the travel market considered here is served by direct flights, the market shares of DB1A and T-100 should be similar.

[11] http://www.transtats.bts.gov.

[12] Travelers accessing the airport by non-car mode (e.g. public transit) represent less than 10% of the overall surveyed sample. See Hess (2004) for a study that examines Bay Area airport mode choice.

from OAK to SNA with WN (Southwest) during the offpeak. For our basic specification, a traveler's choice is modeled as the maximization of the indirect utility function (1). Let the following sets denote departure airports, arrival airports, airlines, and time periods:

$$i \in \{OAK, SFO, SJC\}$$
$$j \in \{BUR, LAX, ONT, SNA\}$$
$$k \in \{UA, WN, Other\}, \text{ where } Other = \{AS, DL, HP, QQ, US\}$$
$$t \in \{Peak, Offpeak\}$$

The indirect utility of a specific alternative then is :

$$\begin{aligned} V_{i,j,k,t} = & \sum_{i \neq SFO} \beta_i D_i + \sum_{j \neq LAX} \beta_j D_j + \sum_{k \neq Other} \beta_i D_i \\ & + \beta_1 Fare + \beta_2 Freq. + \beta_3 Access + \beta_4 Delay \\ & + \beta_5 Inc\_group\_2 + \beta_6 Inc\_group\_3 \\ & + \sum_j \beta_{early,j} D_{early,j} + \sum_j \beta_{late,j} D_{late,j} \\ & + \varepsilon_{ijkt} \end{aligned} \tag{1}$$

The specification is estimated in a weighted conditional logit model for all, for business and for leisure travelers. The distinction between traveler types is relevant, so we treat the separate estimates as the preferred ones, and omit the results for "all travelers" for the sake of brevity. Using the same data, we estimate a weighted mixed logit model for business and leisure travelers, assuming normal mixing distributions over dummy variables for departure airports and airlines, and over the fare and time cost variables. The weighted mixed logit model relaxes the strict substitution patterns imposed by the weighted conditional logit model (Train, 2003), so its results inform us on the impact of those restrictions. For both models, we use a weighting scheme motivated by Manski and Lerman (1977) to account for biases introduced by the purposely large number of interviews conducted at San Jose Airport ("choice-based sampling"). Market shares based on the DB1A data are used to derive the appropriate weights, the ratios of the respective population and sample market share.

Table 1a Summary statistics for business passengers (935 observations)

Variable	Description	Mean	Std.Dev.	Min	Max
sjc	sjc=1 if departure airport is SJC	0.576	0.494	0	1
oak	oak=1 if departure airport is OAK	0.284	0.451	0	1
wn	wn=1 if airline is WN (southwest airlines)	0.691	0.462	0	1
ua	ua=1 if airline is UA (united airlines)	0.164	0.370	0	1
bur	bur=1 if arrival airport is BUR	0.212	0.409	0	1
ont	ont=1 if arrival airport is ONT	0.151	0.358	0	1
sna	sna=1 if arrival airport is SNA	0.226	0.418	0	1
fare	Average Coach Airfare ($ in 1995)	59.009	12.359	50	182
freq	Average number of flights per hour	1.032	0.801	0.167	4
accetime	Access time (minutes)	24.142	20.008	1.7	125.1
tdelay	Sum of average departure delay and arrival delay	10.374	6.529	1.664	28.275
incgroup2	Fare * income group2 ($75,000-$149,000)	46.803	26.449	0	182
incgroup3	Fare * income group3 ($150,000 or more)	9.867	22.794	0	108
earBUR	Early arrival at Burbank	0.029	0.168	0	1
earLAX	Early arrival at Los Angeles	0.074	0.262	0	1
earONT	Early arrival at Ontario	0.039	0.193	0	1
earSNA	Early arrival at Santa Anna	0.029	0.168	0	1
latBUR	Late arrival at Burbank	0.006	0.080	0	1
latLAX	Late arrival at Los Angeles	0.160	0.367	0	1
latONT	Late arrival at Ontario	0.042	0.200	0	1
latSNA	Late arrival at Santa Anna	0.021	0.145	0	1

Table 1b Summary statistics for leisure passengers (817 observations)

Variable	Description	Mean	Std.Dev.	Min	Max
sjc	sjc=1 if departure airport is SJC	0.355	0.479	0	1
oak	oak=1 if departure airport is OAK	0.512	0.500	0	1
wn	wn=1 if airline is WN (southwest airlines)	0.703	0.457	0	1
ua	ua=1 if airline is UA (united airlines)	0.179	0.383	0	1
bur	bur=1 if arrival airport is BUR	0.190	0.392	0	1
ont	ont=1 if arrival airport is ONT	0.162	0.368	0	1
sna	sna=1 if arrival airport is SNA	0.138	0.345	0	1
fare	Average Coach Airfare ($ in 1995)	56.266	8.997	50	108
freq	Average number of flights per hour	0.626	0.410	0.083	2
accetime	Access time (minutes)	29.887	23.365	2.6	173.9
tdelay	Sum of average departure delay and arrival delay	12.508	6.851	1.664	28.275
incgroup2	Fare * income group2 ($75,000-$149,000)	32.988	28.923	0	108
incgroup3	Fare * income group3 ($150,000 or more)	6.407	18.440	0	76.4
earBUR	Early arrival at Burbank	0.026	0.158	0	1
earLAX	Early arrival at Los Angeles	0.104	0.305	0	1
earONT	Early arrival at Ontario	0.047	0.211	0	1
earSNA	Early arrival at Santa Anna	0.022	0.147	0	1
latBUR	Late arrival at Burbank	0.012	0.110	0	1
latLAX	Late arrival at Los Angeles	0.193	0.395	0	1
latONT	Late arrival at Ontario	0.042	0.200	0	1
latSNA	Late arrival at Santa Anna	0.005	0.070	0	1

Table 1 provides definitions and summary statistics for the explanatory variables, separately for business and leisure travelers. Airport choice is largely explained by access time to the departure airport (accetime), average departure and arrival travel delays (tdelay), and by arrival and departure airport dummies. Access time measures the car travel time (in minutes) between the traveler's initial Bay Area origin and the departure airport. and the access times differ between peak and offpeak flights, reflecting traffic conditions. Travel delays are measured at the airport level, and help determine service quality. Access time and travel delay, together, make up the main non-air-time cost associated with a flight option. The departure airport dummies reflect residual preferences for a given airport beyond its proximity (access time) and its on-time performance. The arrival airport dummies are included to account for different end destinations. This difference in the interpretation of arrival and departure airport dummies occurs because our data are "door-to-arrival airport", not "door-to-door". That is: we observe the Bay Area travel origin of the surveyed travelers but not the corresponding end destination in the Los Angeles area.

Airline choice is largely explained by average transacted fare, flight frequency, and airline dummies. The fare variable reflects the average transacted price for the flight, defined by airline and airport pair, based on the DB1A sample. We interact fare with the traveler's income group, as wealthier travelers are likely less price elastic. Flight frequency is measured as the average number of flights per hour during peak or offpeak hours, per airline-airport combination. Flight frequency can be considered a desirable service quality. Higher frequency provides travelers more departure time options, so reducing costs of deviations from the preferred travel schedule. The potential importance of scheduling considerations also leads us to include dummy variables to indicate the earliest and latest arriving flights at the four L.A. region airports.[13] Travelers flying from the Bay Area to L.A. may prefer early flights as this maximizes the length of stay of short duration trips. Evening flights may be disliked because no later same day flights may be available in case the flight is missed. Since early and late arrival times are determined by airport operating hours and by airline scheduling decisions, these dummy variables for early and late flights help explain both airline and departure airport choice.

[13] Early and late arrival times are arrival airport-specific. For example, the earliest arrival is 7.30 a.m. at SNA, 6.00 a.m. at BUR, and 6.30 a.m. at LAX. IN earlier footnote?

Lastly, we include airline dummies to capture residual preferences for a given airline, beyond its fare, frequency, and early and late availability. We expect airline dummies to matter more for airlines with desirable frequent flyer rewards,as we do not directly observe the frequent flyer affiliation of a surveyed traveler.

Controlling for a fairly large set of demand characteristics helps limit the problem of endogeneity of fares and travel delay, stemming from omitted factors. However, there are other complications associated with fares. First, the airfare used to evaluate the indirect utility associated with a flight option is not the actual airfare quoted to the surveyed traveler, but rather the average transaction airfare for that flight during the studied period. Second, we do not observe when the traveler purchased her ticket. The choice set is based on what we observe *ex post* and not necessarily what was available to the traveler at the time of the booking. We partially address this complication by estimating a separate model for leisure and business travelers, as the choice set is more likely to be common among travelers of similar trip type, with leisure travelers more likely to buy their tickets in advance and business on short notice. Nevertheless, the complications suggest that the strength of the empirical model is in analyzing the role of non-price airport and airline characteristics in air travel choice, controlling for general fare differences, rather than the estimation of particular own and cross price elasticities or values of time.

Table 2 reports estimation results for the basic specification, separately for business and leisure travelers; Table 2a provides coefficient estimates and standard errors, and Table 2b shows marginal effects, which can be compared across subgroups.[14,15] With the exception of some fare related coefficients and a few dummy variables, the coefficients are

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[14] The results are for the weighted conditional logit model. Coefficient estimates for the unweighted model can be found in the appendix. As suggested by Manski and Lerman (1977), the coefficient estimates between the two models differ mainly in the choice specific intercepts. However, the marginal effects, which are a function of all coefficients, differ substantially for all included characteristics. For many marginal effects, ignoring the choice based sampling leads to values that are roughly half of those obtained from a weighted model.

[15] The marginal effects are "own characteristic marginal effects", i.e. the partial derivatives of the probability of the actual choice with respect to a change in that choice's characteristic, taking account of the presence of any interaction terms. For dummy variables, the marginal effects are defined as probability differences. Appendix 2 provides more details.

estimated with good precision, and the signs of the effects correspond to intuition and are largely in line with findings of earlier airport choice models. Alternatives with lower prices, lower access costs, shorter delays and higher flight frequencies are more likely to be chosen than others. Travelers with greater income are found to be less price elastic with respect to average transacted fare.

With respect to flight characteristics affecting airport choice, we find that time costs matter, but not all forms of time costs are valued equally by the surveyed travelers. The marginal effect of an additional unit of access time on the choice probability of a flight is roughly twice that of an additional unit of travel delay, with business travelers modestly more concerned about travel delay than leisure travelers. The greater impact of access time over travel delay may be due to informational constraints; travelers may have more information concerning access time than travel delay, leading to access time being more salient in the decision making. The difference between leisure and business travelers may be due to the fact that the opportunity cost of time for business travelers is foregone work time, while for leisure travelers the disutility of spending time in traffic vs. waiting at the airport is more important. Other possible explanations include differences in risk aversion, with higher access time indicating greater chance of missing flights, differences in information set (with business travelers better perceiving both access time and travel delay), and the even greater hassle of dealing with children in cars than at the airport.

The estimated airport dummies indicate that, even after controlling for time costs, the surveyed travelers have residual airport preferences. SFO is the preferred departure airport and LAX the preferred arrival airport, controlling for included airport characteristics. However, business and leisure travelers disagree on the degree to which the two Bay Area satellite airports (OAK, SJC) substitute for SFO. Business travelers find OAK and SJC to be roughly equal substitutes to SFO, but leisure travelers find OAK to be a much better substitute, controlling for included airport characteristics. This suggests that OAK caters more to leisure travelers and SJC to business travelers, in a manner separate from time cost differences. With respect to arrival airports, both business and leisure travelers find BUR to be a better substitute for LAX than ONT or SNA. This likely reflects the relative proximity of BUR to Los Angeles proper, compared to ONT or SNA.

We find a modest effect of average transacted fare on airline and airport choice.

The estimated fare coefficients and the associated income interactions have the expected negative sign and relative magnitude. However, we find only leisure travelers choice for a particular bundle to be significantly affected by fare. Much of this price elasticity disappears for leisure travelers earning over $75,000. Due to our data limitations, we can only conclude that the leisure travelers respond lightly to general fare differences across available flights and business travelers possibly not at all. Both business and leisure travelers do respond substantially to flight frequency; in fact, we find leisure travelers reacting more to flight frequency than business travelers. A possible explanation, partly supported by the estimates for early and late flight dummies, is that leisure travelers have more diverse preferences over departure times. While both business and leisure travelers have a significant preference for the early flight to LAX and ONT, business travelers also have a preference for late flights to SNA and a distaste for late flights to ONT. This suggests that business travelers have more similar, stronger tastes for particular departure times. The preference for early flights to LAX and ONT exhibited by both traveler types may indicate the demand for short trips; arriving early allows travelers to spend a full day at their destination, even on the day of departure.

The estimates of the airline dummies for United and Southwest Airlines, suggest that the surveyed travelers have a residual preference for these airlines. Controlling for included flight characteristics, Southwest is the preferred airline, especially among leisure travelers. This is above and beyond Southwest's lower average transacted fare. The dummy for United is statistically positive for business travelers but not leisure. This suggests that business travelers prefer United over other (non-Southwest) airlines above and beyond United's high flight frequency.[16] The omitted airline characteristic most likely reflected in the airline dummies is the frequent flyer program. These estimates suggest that business travelers value United's nationwide frequent flyer reward more than leisure travelers, but neither traveler type values United's frequent flyer program enough to overcome the residual preference for Southwest. This result may be due to the "short haul" market we are studying, precisely the type of market in which Southwest specializes.

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[16] The negative average marginal effects (probability differences) for United, reported in Table 2b, are due to preference for Southwest over United

Table 2a WESML estimation results for conditional logit model, October 1995

	Business		Leisure	
	Coeff.	std. error	Coeff.	std. error
SJC dummy	-0.6514	0.2973	-1.0901	0.3050
OAK dummy	-0.6900	0.2176	-0.4176	0.2007
WN dummy	1.0990	0.1712	1.0694	0.2124
UA dummy	0.5043	0.1985	0.2406	0.1889
BUR dummy	-0.1827	0.1725	-0.4590	0.1764
ONT dummy	-0.4092	0.2051	-0.8486	0.2185
SNA dummy	-0.3936	0.1996	-0.9105	0.2581
fare	-0.0077	0.0089	-0.0259	0.0102
freq_hour	0.4168	0.1071	0.6322	0.2127
accetime	-0.0815	0.0043	-0.0774	0.0044
tdelay	-0.0498	0.0155	-0.0257	0.0158
incgroup2	0.0040	0.0080	0.0208	0.0093
incgroup3	0.0029	0.0077	0.0088	0.0111
earBUR	0.2614	0.2816	-0.0726	0.3099
earLAX	0.6163	0.2624	0.5644	0.2417
earONT	0.7024	0.2824	0.7705	0.2661
earSNA	0.3166	0.2879	0.3267	0.3636
latBUR	-0.3181	0.3099	-0.0196	0.2596
latLAX	-0.2420	0.2098	-0.3260	0.2083
latONT	-0.5641	0.2622	0.1165	0.2706
latSNA	0.7275	0.3573	-0.2893	0.5816
Number of Obs	935		817	
Log LL	-2,677.19		-2,555.43	

Table 2b Marginal effects (change in probability) for conditional logit model, October 1995

Variable	Business	Leisure
sjc	-2.787	-5.307
oak	-2.499	-1.257
wn	4.450	5.970
ua	-0.650	-2.322
bur	-0.266	-1.720
ont	-1.582	-4.125
sna	-1.613	-3.763
fare	-0.024	-0.091
freq	2.368	4.241
accetime	-0.463	-0.519
tdelay	-0.283	-0.172
incgroup2	1.193	8.072
incgroup3	-0.073	-0.490
earBUR	0.021	-0.005
earLAX	0.360	0.447
earONT	0.072	0.096
earSNA	0.014	0.010
latBUR	-0.044	-0.004
latLAX	-0.374	-0.769
latONT	-0.121	0.026
latSNA	0.165	-0.004
Number of Passengers	935	817

Table 3 Weighted Mixed logit estimation results: Weekday travel, October 1995

Distribution assumption	Variable	Business		Leisure	
		coeff.	std.error	coeff.	std.error
Normal Distribution	SJC mean	-0.7091	0.2624	-1.5993	0.2958
	SJC std	0.0022	0.0092	0.0191	0.0404
	OAK mean	-0.6637	0.2025	-0.4334	0.1818
	OAK std	0.0080	0.0093	0.0117	0.0391
	WN mean	1.1066	0.2198	1.2861	0.3566
	WN std	0.0291	0.0255	1.0544	1.0392
	UA mean	0.5223	0.1990	0.0432	0.3631
	UA std	0.0116	0.0234	1.4641	1.2924
	fare mean	-0.0094	0.0141	-0.0214	0.0142
	fare std	0.0084	0.0145	0.0000	0.0027
	freq mean	0.4205	0.1301	0.7191	0.2232
	freq std	0.0228	0.0400	0.0429	0.0774
	Accetime mean	-0.1023	0.0096	-0.1314	0.0179
	Accetime std	0.0451	0.0101	0.0820	0.0150
Fixed Coefficients	BUR	-0.2262	0.1649	-0.5614	0.1696
	ONT	-0.4742	0.2046	-0.9874	0.2123
	SNA	-0.4350	0.2135	-1.1700	0.2561
	tdelay	-0.0539	0.0150	-0.0484	0.0167
	Inc2	0.0044	0.0085	0.0203	0.0133
	Inc3	0.0030	0.0075	0.0050	0.0100
	earBUR	0.3559	0.2479	0.1384	0.2884
	earLAX	0.6640	0.2424	0.6705	0.2335
	earONT	0.8050	0.2700	1.0836	0.2774
	earSNA	0.3996	0.2284	0.6253	0.3204
	latBUR	-0.3295	0.5255	-0.1009	0.4708
	latLAX	-0.2868	0.1964	-0.3883	0.1848
	latONT	-0.5820	0.3271	0.0172	0.3385
	latSNA	0.6820	0.4576	-0.3265	0.6168
LogL		-2669.3487		-2521.8066	
Number of Obs		935		817	

Table 3 presents the estimates from a weighted "mixed logit" model, for a specification identical to the one estimated with the conditional logit, except that we allow some coefficients to vary randomly according to a normal distribution, thus allowing for greater unobserved variation in preferences.[17] We use a weighting scheme similar to before in order to account for the choice-based sampling. We mix the three departure airport dummies, the two airline dummies, and the two "value of time" characteristics of access time and travel delay. Estimation difficulties prevent us from estimating a more generally mixed model. The main result is that, with the exception of the airline dummies for

[17] See Train (2003) for more details on the Mixed Logit model. The asymptotic properties of the weighted mixed logit models are based on results in Wooldridge (2001).

leisure travelers, the weighted mixed logit yields results similar to those from the weighted conditional logit. In particular, the random coefficients are largely centered at the conditional logit estimates with small estimated standard deviations. This result contrasts those reported in other airport choice studies (cf. Hess and Polak, 2005) and suggests that our focus on a single market and trip type accounts for much of the consumer preference heterogeneity in the sample.[18] The large variation in preference for airlines by leisure travelers probably reflects the adoption of different frequent flyer programs.[19] However, the large standard deviations are estimated imprecisely. We find little evidence suggesting that a weighted mixed logit model substantially outperforms the weighted conditional logit model after controlling for market and trip type. On the basis of this judgment, we calculate the counterfactual scenarios using the weighted conditional logit estimates.

4. Counterfactual scenarios

In the previous section, we examined how different flight characteristics affect a traveler's flight choice. The estimates reveal that no one characteristic strictly dominates the choice. This insight is further corroborated in a simple examination of the chosen flights. Only 47.49% of the sampled business travelers and 52.63% of the sampled leisure travelers chose a flight departing from the closest airport (closest in terms of access time). Moreover, only 52.3% of business travelers and 68.3% of leisure travelers chose a flight whose average transacted fare was within $5 of the lowest such fare. This indicates that the surveyed travelers do not exhibit lexicographic preferences; they do not simply choose flights that depart from the closest airport or offer the cheapest fare. There are important avenues for substitution across the different airline and airport characteristics.

In this section, we consider three counterfactual scenarios that demonstrate such substitution. The first two scenarios illustrate the importance of time costs to airport substitutability. In the first scenario ("Access SFO") ground access times to SFO are reduced by 5 minutes. In the second scenario ("Delay SFO") delays for flights from SFO are reduced by 5 minutes. The third scenario is a more radical departure, considering the

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[18] We found the mixed logit results to be robust to different initial values.

[19] Analogously, the small standard deviation for the mixing distribution for airlines for business travelers suggests most business travelers have similar frequent flyer participation.

effect of entry by Southwest Airlines into SFO. Travelers no longer need to choose between departing from SFO (the seemingly preferred airport) and flying with Southwest Airlines (the seemingly preferred airline). Since we have no explicit model of supply, four polar cases of the third scenario are calculated: in version A ("duplicate, accommodate") Southwest duplicates its 1995 operation at OAK in SFO and there is no price response from UA (its main competitor); in version B ("transfer, accommodate") Southwest transfers its entire OAK operation to SFO, and UA sticks to its prices. In version C ("duplicate, match") Southwest duplicates in SFO and UA responds by adopting Southwest's prices; in version D ("transfer, match") Southwest transfers its operation from OAK to SFO, and UA adopts the Southwest prices. In all versions, Southwest charges the same prices at SFO that it in fact charged at OAK, and airlines other than United Airlines do not change their prices or service levels.[20]

Table 4 compares the results from the counterfactual scenario to the predicted values of the estimated model (baseline) rather than to the observed values. We report market shares for business, leisure, and all travelers. The scenarios take the decision to travel by air as given, so they only consider substitution between travel alternatives in response to a change in travel options or travel costs, abstracting from substitution effects with an outside good. This may be a reasonable assumption for business travelers, whose demand for air travel is fairly inelastic.[21]

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[20] Ito and Lee (2004) find incumbent response to low cost carrier entry to be fairly accommodating.

[21] For those scenarios that involve reduced air travel costs, the counterfactuals provide a lower bound for the favorable change in demand for SFO and SFO-based carriers (UA), as some consumers who previously chose not to fly may be induced to fly due to the improved choices offered at SFO. The counterfactual involving Southwest transferring its operation from OAK to SFO does not provide intuitive bounds as some travelers' observed choices are altered while new options are introduced.

Table 4 Key results for counterfactual scenarios: percentage market shares *

Model	Baseline	Access SFO	Delay SFO	Southwest SFO UA accommodates		Southwest SFO UA matches	
				Duplicate	Transfer	Duplicate	Transfer
				A	B	C	D
Leisure only							
% from SFO	27.1	33.5	29.1	46.5	66.2	62.4	78.6
% from SJC	20.0	18.4	19.5	15.4	19.1	11.3	13.0
% from OAK	53.0	48.1	51.4	38.1	14.7	26.3	8.4
% with UA	29.5	33.5	30.8	18.6	29.6	46.0	59.3
% with WN	57.8	52.7	56.2	73.0	58.8	48.4	33.8
% with other	12.7	13.8	13.0	8.4	11.6	5.6	6.9
Business only							
% from SFO	31.4	37.7	35.2	45.0	56.6	49.1	60.1
% from SJC	36.1	33.8	34.8	31.1	34.7	29.4	32.4
% from OAK	32.5	28.4	30.0	24.0	8.8	21.5	7.5
% with UA	32.7	37.5	35.6	20.6	27.8	28.5	36.4
% with WN	54.1	49.1	51.1	69.3	60.1	62.3	52.7
% with other	13.2	13.4	13.3	10.1	12.1	9.2	10.9
All passengers							
% from SFO	29.3	35.7	31.4	45.9	61.1	55.4	69.0
% from SJC	28.1	26.3	27.5	23.2	26.9	20.0	22.4
% from OAK	42.5	38.0	41.0	30.9	12.0	24.7	8.6
% with UA	31.1	35.5	32.6	19.5	28.4	36.7	47.1
% with WN	55.9	50.8	54.2	71.4	60.0	56.2	44.1
% with other	13.0	13.7	13.2	9.1	11.6	7.1	8.8

* The results are based on the models estimated on the entire sample and on subsamples for business travelers or leisure travelers. The reported shares are the weighted average across the 500 simulations (numerical integration of the additive logit error), with weights equal to those of the estimation model. For the common choices, the same shocks were used for all 5 cases. For SFO Southwest, additional shocks were generated for the new choices (SFO-WN). The rationale is that the shocks are largely unobserved passenger characteristics.

Reducing access times at SFO by five minutes increases the overall market share of SFO from 29% to 36%. The effect of reducing delays by the same amount is positive as well, but smaller (the SFO market share rises to 31%). This result is consistent with our earlier finding that access time matters more than travel delay. Moreover, we find business travelers responding more to travel delay than leisure travelers, with shorter access time inducing a 4.4% greater increase than shorter delays, in the SFO market share for leisure travelers, but only a 2.5% greater increase for business travelers. Business and leisure travelers also differ in the airport that suffers the most from the improved SFO time cost. Among leisure travelers, much of SFO's increased market share comes at the cost of OAK. Flights departing from SJC are relatively unaffected. Among business travelers, SJC is more substantially affected. This reiterates the earlier finding that leisure travelers find OAK to be much more of a substitute for SFO.

Table 4 also shows United Airlines as being the primary beneficiary of the improved time cost at SFO, with its overall market share improving 4.4% due to the reduction in access time and 1.5% due to the reduction in travel delay. This is due to United's "dominance" of SFO. While some of the increased United-SFO demand cannibalizes United-OAK operations, the majority comes from Southwest-OAK operations. This demonstrates the demand-side impact that even a modest change in airport substitutability can have on airline competition. Southwest's decision not to operate in SFO, often attributed to SFO's greater travel delay, depends on the continued view of OAK as an adequate substitute for SFO. We explore this issue explicitly in the third counterfactual scenario.

We consider entry of Southwest at SFO along two dimensions: [1] whether Southwest duplicates or transfers its OAK operations to SFO [2] whether United accommodates (maintains same price) or matches Southwest's low fare at SFO. All other airlines are assumed to maintain their same operations. When Southwest duplicates its OAK operations, travelers with a preference for Southwest no longer need to trade-off desirable Southwest airline characteristics with desirable departure airport characteristics as Southwest now flies out of all three major Bay Area airports.[22] However, when Southwest

[22] But Southwest does not fly to all four LA area airport from each of the three Bay Area airports

transfers its OAK operations to SFO, travelers face a different trade-off – between flying Southwest or departing from OAK. For travelers preferring SFO to OAK, this new trade-off is an improvement but for those preferring OAK to SFO, the trade-off may be binding. When United matches Southwest's low fare at SFO, travelers no longer need to trade-off between flying United at SFO and paying a low fare.

Entry of Southwest at SFO has potentially large effects on its market share, depending on United's reaction. If Southwest enters at SFO and retains its operation at OAK, and United accommodates, the overall market share of Southwest increases from 56% to 71%. Travelers who prefer Southwest's low fare but fly non-Southwest in order to depart from SFO can now fly SFO and pay Southwest's low fare. But if United price matches Southwest, such duplication hardly affects Southwest's market share.[23] More travelers depart from SFO (from 29% to 55%) but not necessarily with Southwest. Southwest transferring its operations from OAK to SFO modestly improves Southwest's market share (+4%), but only if United accommodates. When United matches Southwest's low fare at SFO, a transfer leads to Southwest losing market share (-12%). Travelers with strong preference for OAK switch away from Southwest and, without the fare difference, United with its high flight frequency is a tough competitor for Southwest at SFO.

Inspection of the effects by type of traveler shows that price matching under duplication leads to an increase of Southwest's business market share (from 54% to 62%), and a reduction of its share in the market for leisure travel (from 58% to 48%). If Southwest abandons OAK in favor of SFO, price matching by United leads to a reduction of Southwest's business and leisure market share. The loss is large for leisure travel, and small for business travel. The larger loss from leisure travelers reflects the greater price elasticity and response to flight frequency exhibited by such travelers. Under price matching, leisure travelers no longer need to choose low fare (Southwest) over high frequency (United). Southwest loses business market share only when it transfers operations as business travelers with strong preference for OAK choose to depart OAK instead of fly with Southwest. This preference to OAK is due, in part, to the greater

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[23] None of these scenarios indicate irrational behavior on Southwest or United's behalf, as we neglect any costs associated with duplicating or transferring operations and firms maximize profits, not quantity sold.

distaste for travel delay exhibited by business travelers; SFO suffers greater average travel delays than OAK.

Lastly, we note that much of SFO's market share gain due to Southwest's entry comes at the cost of OAK. SJC also suffers in all entry scenarios, especially when United price matches, but less than OAK. This reiterates our earlier finding of greater substitutability between OAK and SFO, than SJC and SFO. Leisure travelers are more likely to change airports due to Southwest's entry than business travelers. This suggests that airports are, overall, more substitutable for leisure travelers than business travelers.

5. Conclusion

We study travelers' choices of airport-airline bundles for trips from the San Francisco Bay Area to greater Los Angeles, by estimating weighted conditional logit and mixed logit models of airport and airline choice, using data for October 1995. A first key finding is that consumers do not separately choose an airline and an airport but rather choose among imperfect airline-airport substitutes. Secondly, the way passengers trade off the airline and airport attributes depends on whether they travel for business or leisure purposes.

Specifically, business and leisure travelers care about time costs associated with an airport, and both show greater distaste for access time than travel delay. Even modest changes in these time costs, such as a 5 minute reduction, can induce noticeable shifts in air travel demand at an airport and for the airlines serving that airport. Both types of travelers appreciate flight frequency and this helps enable United Airlines to charge higher fares than much of its competitors in the Bay Area to greater Los Angeles market. This is especially true for leisure travelers, who are more fare elastic but also appreciate flight frequency more. We find a balance maintained between United Airlines and Southwest Airlines. United offers high frequency flights out of a desirable airport (San Francisco) while Southwest offers low fare flights out of satellite airports. This balance forces travelers to make binding trade-offs among desirable airline and airport characteristics, and it allows United and Southwest to compete indirectly.

Our focus in this paper is on the joint relevance of airline and airport characteristics, and the basic finding is that neither can be ignored when analyzing the market for air travel between the Bay Area and greater L.A. By extension, the appropriate definition of the market for travel from or to a multi-airport region, is at the level of the region rather than at the level of an airport. This result merits attention in studies of airport governance and of airline competition in multi-airport regions. For example, the airline passenger survey that forms the core of our dataset, is conceived by the Metropolitan Transportation Commission as a tool for strategic airport management in the Bay Area. The survey contains a wealth of detail on passengers' choices of access mode, but information on flight choice is more rudimentary. Similarly, efforts are made to generate a sample which allows useful analysis at the level of an airport, but less is done to ensure adequate coverage of airlines at each airport (forcing us, for example, to omit the entire August wave of the sample). Our empirical results indicate that a good understanding of passengers' choices for a particular airport requires taking account of airline characteristics. Furthermore, passengers' choices affect airlines' response to airport decisions regarding, for example, capacity.

It becomes more important for airports to be aware of how passengers and airlines might react to their decisions, when airports become more independent from airlines. A trend towards increased airport independence has been documented by FAA/OST (1999) and is partly explained by the increased business risk associated with reliance on one or a few major airlines, when these airlines are highly susceptible to bankruptcy. With such increased vertical separation between airlines and airports, an understanding of how passengers trade off airport and airline characteristics, and how airlines in turn may respond in terms of services offered, seems important, especially for airports that compete with nearby airports. Our counterfactual scenarios illustrate how airlines' decisions to enter at a nearby airport, while retaining or omitting service at the current airport, may have major effects on airports' market shares. Recent experience at the airports of Pittsburgh and Cincinnati, where dominant carriers rejected leases under Chapter 11 protection, shows that such drastic airline actions can indeed occur, and common sense suggests they are more likely to occur in multi-airport regions.

Taking account of the joint importance of airport and airline characteristics in multi-airport regions is not only important from the point of view of the airport, but also for understanding airline competition in such a region. For example, one of the counterfactual scenarios suggests that Southwest Airlines would lose a substantial part of its market share if it transfers its operations to San Francisco, and United Airlines matches the Southwest fares and retains its high frequency of service. The loss of market share is particularly high in the market for leisure travel. These results indicate that Southwest's choice to concentrate its offerings in Oakland is not necessarily made on cost grounds alone, but that demand-side factors matter as well.[24] One may ask why United Airlines decides to offer service to L.A. from Oakland as well as from San Francisco, as this is not immediately clear from our results. Further research on how airlines choose to compete and engage in product differentiation through offering various airport-flight combinations seems warranted.

A specific focus on multi-airport regions is justified in the sense that some 40% of all departing passenger in the U.S. depart from a multi-airport region (Van Dender, 2006). Further growth in the demand for air travel is likely to increase this share, as new airports need to be built in places where expansion of the existing ones is very costly. In addition, the air transportation industry is undergoing changes that will further alter the substitutability of competing airports in multi-airport region. For example, Southwest is challenging flight restrictions (Wright Amendment) that prevents it from offering nationwide service out of Dallas Love Field. Relaxation of the Wright Amendment would make Dallas Love Field a better substitute for Dallas Fort Worth Airport (DFW) and Southwest, the dominant airline at Love Field, a better substitute for American, the dominant airline at DFW. Furthermore, Southwest Airlines has increasingly entered hub airports. Southwest recently announced plans to operate out of Washington Dulles. This new plan would relax the current trade-off between flying Southwest and flying into/out of one of the local, Washington D.C. airports. Our estimates suggest that, given the importance of access time, the competitive influence of Southwest on other airlines will be magnified by this new entry, especially with respect to travelers based in Virginia. But the end market equilibrium will depend on the exact bundles offered by the other airlines vis-à-vis Southwest.

[24] Cost factors likely matter as well. Van Dender (2006) finds that aeronautical charges, like landing fees and terminal rents, are lower at airports dominated by Southwest.

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Appendix 1 Construction of the variables

1. ACC_T: airport access time by car

   - Find which TAZ matches to SFO, SJC, and OAK

   The MTC airline passenger survey records the travel analysis zone (TAZ) for each passenger who was interviewed. The MTC maintains a set of travel analysis zones for use in MTC planning studies. These TAZs are typically small area neighborhoods or communities that serve as the smallest geographic base for travel demand model-forecasting systems. The zone system used in the MTC survey is the 1099 zone system developed in 1993. The MTC 1099 zone is equivalent to the 1990 census tract. The 1990 census tract information can be found in Bay area census website (www.bayareacensus.ca.gov). From the file which compares TAZ and census tract (ftp://ftp.abag.ca.gov/pub/mtc/), SFO, SJC, and OAK match "165", "323", and "647" respectively.

   - Use "Zone-to-Zone travel times and distances for auto" data to get "ACC_T"

   We find travel times depending on which time of day a passenger drives and on the vehicle occupancy rate. For example, if a passenger drives during peak hours and reports that two people were in vehicle, we use peak-hour driving time for ride 2.

2. FREQ: frequency of service

   Using OAG data, we first calculate the number of flights depending on the departure time and the day of week. We count the number of flights within peak hours (6-9 AM and 3-6 PM) or off-peak hours (all remaining hours). Then we divided the number of flights by 6 or by 18 to get frequency per hour.

3. FARE

   We use Severin Borenstein's DB1A fourth quarter 1995 average fares for direct flights

4. DEL_T

   The departure and arrival delays for all flights flown out of (SFO, SJC, OAK) to (BUR, LAX, ONT, SNA) for (August, October) of 1995 were used to calculate the monthly mean departure delay and the monthly mean arrival delay for each combination of origin and destination airport. DEL_T is the sum of average departure delay and arrival delay by peak and off-peak. Cf. http://www.transtats.bts.gov

Appendix 2 Marginal Effects Calculation

The average marginal effects reported in Table 2b are based on the "own characteristic" marginal effects of each sampled traveler's observed choice. The marginal effects are calculated in the manner described below for each sampled traveler. The marginal effects are then averaged using the same weights as in estimation. The weights help extrapolate the average to the population, rather than the sample (which over-represents travelers choosing San Jose Airport).

For airline/airport characteristics that are continuous, the own characteristic marginal effect is the probability derivative, $\beta_k P_{ij} (1- P_{ij})$, where β_k is the estimated coefficient for characteristic k and P_{ij} the estimated probability of traveler i choosing observed choice j. For airfare, the income interaction is properly incorporated into the derivative calculation.

For discrete airline/airport characteristics, the own characteristic marginal effect is the discrete difference in the estimated probability of the observed choice.

For airport dummies, it is the difference in the estimated probability assuming the observed choice flew out of the considered airport versus the estimated probability assuming the observed choice flew out of the actually observed airport. In the case where the actual and considered airports are the same, the actual airport is substituted with the excluded airport (SFO for departure airports and LAX for arrival airports). All other airport/airline characteristics are held the same as the observed choice.

For airline dummies, it is the difference in the estimated probability assuming the observed choice was with the considered airline versus the estimated probability assuming the observed choice was with the actually observed airline. In the case where actual and considered airlines are the same, the actual airport is substituted with the excluded airline (non-Southwest, non-United). All other airport/airline characteristics are held the same as the observed choice.

Appendix 3: Unweighted conditional logit estimates

	All		Business		Leisure	
	Coef.	Std. error	Coef.	Std. error	Coef.	Std. error
sjc	0.1428	0.1718	0.4281	0.2547	-0.1598	0.2534
oak	-0.0106	0.1265	-0.1418	0.1952	0.0118	0.1793
wn	1.1582	0.1103	1.0094	0.1494	1.0188	0.1837
ua	0.4241	0.1140	0.4180	0.1784	0.1552	0.1680
burbank	-0.3968	0.0996	-0.2276	0.1414	-0.5619	0.1477
ont	-0.6469	0.1196	-0.3662	0.1666	-0.8519	0.1792
oc	-0.5646	0.1265	-0.3214	0.1652	-0.8142	0.2139
fare	-0.0270	0.0066	-0.0178	0.0091	-0.0396	0.0106
freq_hour	0.3339	0.0754	0.5174	0.0998	0.8781	0.2040
accetime	-0.0808	0.0026	-0.0777	0.0035	-0.0815	0.0039
tdelay	-0.0341	0.0088	-0.0556	0.0128	-0.0396	0.0133
incgroup2	0.0147	0.0059	0.0027	0.0078	0.0174	0.0094
incgroup3	0.0105	0.0061	0.0091	0.0077	0.0151	0.0115
earBUR	0.3161	0.1674	0.4809	0.2251	0.0936	0.2541
earLAX	0.8128	0.1424	0.7219	0.2142	0.4924	0.2052
earONT	0.9682	0.1546	0.9712	0.2212	0.9192	0.2175
earSNA	0.5037	0.1661	0.4992	0.2160	0.6248	0.2643
latBUR	-0.8912	0.2639	-1.0131	0.4267	-0.7636	0.3392
latLAX	-0.1040	0.1112	-0.2267	0.1661	-0.3803	0.1678
latONT	-0.3658	0.1601	-0.7619	0.2275	-0.1597	0.2300
latSNA	0.6984	0.2895	1.3110	0.3778	0.3721	0.6220
Number of Obs	1752		935		817	
Log LL	-5146.5655		-2745.2628		-2354.6147	