# Are Air Travel Markets Segmented Along the Lines of Nonstop versus Intermediate-stop(s) Products?

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**Abstract**

Proper antitrust analysis often depends on whether the concerned differentiated products are truly competing with each other. We estimate a structural econometric model to investigate whether nonstop and connecting air travel products effectively compete with each other. Estimates suggest that connecting products may be an attractive alternative to nonstop products for leisure travelers but less so for business travelers. If connecting products are counterfactually eliminated, our model predicts small price changes for nonstop products, suggesting that the two product types only weakly compete with each other and can be treated as being in separate product markets for antitrust purposes.

K*eywords:* Substitutability between Differentiated Air Travel Products; Market Segmentation; Relevant Product Markets; Discrete Choice Demand Model

*JEL Classification codes*: L13, L25, L93

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## 1. Introduction

In evaluating a proposed merger, the U.S. Department of Justice (DOJ) normally identifies relevant product markets in which the merger may "substantially lessen competition".[1] Regarding the merger enforcement standards in the airline industry, the DOJ has published a document stating the following: [2]

"*...there are many city pairs that are served by some carriers on a nonstop basis and others on a connecting basis, which poses the following question: is a passenger having the ability to take a nonstop flight likely to regard connecting service as a reasonable alternative, such that he or she would switch from nonstop service offered by one carrier to connecting service offered by another carrier if the first carrier raised its fare?"*

This statement indicates that at the heart of conducting proper antitrust analysis in the airline industry is the question of whether nonstop and intermediate-stop(s)/connecting air travel products are truly competing with each other, or put another way: Can these two types of air travel products be treated as being in the same market segment? This paper intends to shed light on this very important antitrust-relevant question. To the best of our knowledge, there is no formal empirical analysis of this issue in the literature, even though some researchers have separately analyzed competition between nonstop products from competition between intermediate-stop(s) products [e.g. see Brueckner et al. (2011)].

A typical air travel origin-destination market contains a menu of nonstop and intermediate-stop(s) products from which potential consumers choose. If these two differentiated products are considered being in the same market segment, then consumers should be willing to substitute between these products in response to relative changes in price. Under

[1] See the Horizontal Merger Guidelines published by U.S. Department of Justice and Federal Trade Commission (2010). http://www.justice.gov/atr/public/guidelines/hmg-2010.html.
[2] U.S. Department of Justice (2000), "Statement of John M. Nannes, Deputy Assistant Attorney General, Antitrust division, Before the Committee on Transportation & Infrastructure, U.S. House of Representatives, Concerning Antitrust analysis of Airline Mergers." http://www.justice.gov/atr/public/testimony/4955.htm.

such circumstance, the intermediate-stop(s) products can have significant competitive impact on nonstop products. On the other hand, if the market is segmented along the lines of nonstop versus intermediate-stop(s) products, there is likely to be low consequential competitive effect between these two product types.

Berry and Jia (2010) provides evidence suggesting that in recent time consumers have an increasingly strong preference for nonstop products compared to intermediate-stop(s) products in the airline industry. Gillen et al. (2003) conduct a report of air travel demand elasticities for Canada. They suggest that the demand for air travel should be distinguished by types of consumers (leisure vs. business travelers), length of haul (short-haul vs. long-haul distance), and types of markets (domestic vs. international destinations). So in addition to a general investigation of market segmentation along the lines of these product types, it might be useful to see if the result of the investigation depends on length of market haul or types of consumers. The following quote from a DOJ published document further motivates breaking down the analysis by consumer types: [3]

"*...**Chances are** that passengers traveling for leisure -- on vacation perhaps -- are more likely to consider switching; their demand is said to be more elastic. However, passengers making business trips are significantly less likely to regard connecting service as a reasonable alternative...*"

The challenge we face in breaking down the analysis by consumer type is that publicly available data, like the Airline Origin and Destination Survey (DB1B) which we use, do not provide information about consumers' purpose of travel (e.g. business versus leisure). As such, in the spirit of recent literature on differentiated products demand, we use a structural

[3] U.S. Department of Justice (2000), "Statement of John M. Nannes, Deputy Assistant Attorney General, Antitrust division, Before the Committee on Transportation & Infrastructure, U.S. House of Representatives, Concerning Antitrust analysis of Airline Mergers." http://www.justice.gov/atr/public/testimony/4955.htm.

econometric model to capture consumers' heterogeneity in tastes.[4] Modeling consumers' heterogeneity is important for more accurate estimation of demand elasticity and the corresponding product markups and marginal cost.

Our econometric estimates suggest that consumers' ideal air travel product is a cheap nonstop flight between their origin and destination. When we decompose consumers' choice behavior according to leisure versus business travelers, the result suggests that these two types of consumers view a product differently with respect to their marginal utilities of price. Leisure travelers are much more price-sensitive compared to business travelers irrespective of whether the market is short-haul, mid-haul, or long-haul distance travel.

The statistically significant cross-price elasticity of demand estimates suggest that, on average, consumers perceive intermediate-stop(s) products substitutable for nonstop products. Furthermore, when facing an increase in price of nonstop products, we find that leisure travelers are more willing than business travelers to switch to intermediate-stop(s) products, suggesting that leisure travelers are more willing to tolerate intermediate stops compared to business travelers.

We use the estimated econometric model of air travel demand and supply to perform an equilibrium counterfactual analysis, which helps us better evaluate whether nonstop and intermediate-stop(s) products can be treated as being in separate market segments. Essentially the counterfactual experiment is done by removing intermediate-stop(s) products from each sample market, then assuming the previously estimated product marginal costs and preference parameters are unchanged, we use the supply-side of the model to solve for new equilibrium prices for nonstop products. A comparison of the actual nonstop products' prices with their

[4] We follow Berry and Jia (2010) approach, but for more flexible consumer heterogeneity specifications see Nevo (2000) and Petrin (2002).

model predicted equilibrium prices when intermediate-stop(s) products are counterfactually removed reveals the extent to which the presence of intermediate-stop(s) products influences the pricing of nonstop products. The counterfactual analysis reveals the existence of three effects that might simultaneously influence the predicted equilibrium price change of nonstop products if competing substitute products are removed from the market counterfactually: (1) a market power effect; (2) a multi-product firm effect; and (3) a price-sensitivity effect.

The market power effect is the most straightforward of the three effects to understand. The idea is that carriers who remain in the market with nonstop products may raise the price of these products owing to increased demand and market power which stem from fewer competing substitute products in the market. On the other hand, if the product that is removed from the market is one of several substitute products offered by a firm, this firm has an incentive to marginally reduce the price on its remaining products. We call this downward price pressure the multi-product firm effect. The other downward pressure on the price of nonstop product occurs when the average price-sensitivity of the set of potential consumers of these products increases. By eliminating intermediate-stop(s) products, we in effect force carriers to optimally adjust the price of nonstop products for those consumers who are more price-sensitive and do not have any other product options. We call this effect on the price of nonstop products the price-sensitivity effect. In summary, the net effect on the price of nonstop products if intermediate-stop(s) products are removed from the market depends on which of the three effects dominate.

The result from our counterfactual exercise shows that most markets are predicted to have either no price change or price decreases, and among the markets with predicted price increases, these price increases are typically smaller than 1%. Overall, the predicted price changes for nonstop products typically lie between -1% and 1%. The evidence therefore suggests that the market power effect is often offset by the multi-product firm effect and price-sensitivity effect. Furthermore, the small net price changes suggest that nonstop and intermediate-stop(s) air travel products can be treated as being in separate product markets for antitrust purposes.

The rest of the paper is organized as follows: Important definitions used throughout the paper are collected in Section 2. Section 3 describes the data used in estimation. Sections 4 and 5 outline the econometric model and the estimation technique respectively. We discuss results in Section 6, and offer concluding remarks in Section 7.

## 2. Definitions

We now define some key concepts that are used throughout the paper. A market is directional air travel between origin and destination airports, independent of any intermediate stops. Thus, a trip from Kansas City to Atlanta is considered a different market than a trip from Atlanta to Kansas City. This direction-specific approach of defining air travel markets allows origin city characteristics to influence demand. For example, origin cities that differ in population density and proportion of business versus leisure travelers are likely to have different demands for air travel.

A trip itinerary refers to a specific sequence of airport stops in traveling from the origin to destination airport. An air travel product is defined as the combination of a trip itinerary and airline. In a given market, airlines often compete with each other by offering a variety of products. For example, varied products in the Atlanta to Kansas City market are: (1) a nonstop trip operated by American Airlines; (2) a nonstop trip operated by Delta Airlines; and (3) a trip that requires an intermediate stop in Chicago operated by American Airlines. In other words, an air travel carrier can offer several distinct products in a given market, as in the example above in which American Airlines offer both a nonstop product along with a product that requires an intermediate stop in Chicago.

For any given product, the responsibilities of a "ticketing" carrier are different from those of an "operating" carrier. A ticketing carrier is an air travel carrier that markets and sells the flight ticket for a product to consumers, while an operating carrier is the one that actually transports the passengers. For most products, typically labeled in the literature as pure online products, a single carrier is the ticketing and operating carrier, while for other products, some of which are referred to as codeshare products, the ticketing and operating carriers differ.[5] In this research we treat the ticketing carrier as the "owner" of the product since this is the carrier that offers the product for sale to the consumer.[6]

## 3. Data

Data are obtained from the Airline Origin and Destination Survey (DB1B), published by the U.S. Bureau of Transportation Statistics. DB1B is a 10% random sample of airline tickets from reporting carriers in the U.S. The database includes identifying information for ticketing and operating carriers associated with each ticket, the ticket fare and the number of passengers that purchase each ticket, the origin and destination airports as well as the sequence of any intermediate airport stop(s) that each itinerary may use, total itinerary flight distance, and the nonstop flight distance between the origin and destination airports. The data do not contain any passenger-specific information such as whether the passenger holds frequent-flyer membership

[5] See Ito and Lee (2007), Gayle (2011, 2008, 2007a and 2007b) for discussions of the various types of air travel products and their relative popularity in US domestic air travel markets.
[6] In relatively rare occasions products with intermediate stops may have different ticketing carriers for each trip segment, but we do not consider such products in our analysis. The products considered in our analysis have a single ticketing carrier for all trip segments.

with an airline, whether the purpose of the trip is for business or leisure, date of ticket purchase, how long in advance of travel date ticket was purchased, etc. Data in our study are focused on U.S. domestic flights offered and operated by U.S. carriers in the 1st quarter in 2010.

Some data restrictions are imposed in our study. Observations are dropped with missing market fares and market fares less than $100 due to the high probability that these may be data entry coding errors or discounted fares that may be related to passengers using accumulated frequent-flyer miles to offset the full cost of travel. Only products between the 48 main land U.S. states are included. In addition, flight itineraries with a change in the ticketing carrier or the operating carrier are eliminated. In order for a product to remain in our sample we require that at least 5 passengers purchase it during the quarter. In addition, we drop the relatively rare occasions when products have 3 or more intermediate stops since in these instances the intermediate stops may themselves be destinations of importance for the passenger rather than a mere route to get the passenger to their final destination. In other words, consumers that purchase products with 3 or more intermediate stops are unlikely to perceive products with fewer, or no, intermediate stop as substitutable with the chosen product since the final destination may not have been the only destination of importance for the passenger. Given that the main objective of our analysis is to investigate the extent to which nonstop products are substitutable with intermediate-stop(s) products, including products with 3 or more intermediate stops may unduly bias our results towards finding weak substitutability.

In order to collapse the data based on our definition of air travel product, we compute the mean price for each distinct itinerary-carrier combination. Thus, a product's "*price*" is the mean ticket fare for its unique itinerary-carrier combination. Also, a "*quantity*" variable is created based on the sum of passengers that purchase the product. This variable is used to construct observed product shares, which is defined as product "*quantity*" divided by the potential market size[7]. The final dataset has sample size of 10,883 products spread across 741 origin-destination markets.

We then construct some product characteristics variables. An "*Interstop*" variable is the number of intermediate stops in each product. A measure of product "*Inconvenience*" is created as the ratio of the total itinerary flight distance to the nonstop flight distance between origin and destination. The minimum possible value of the *Inconvenience* variable is 1, indicating the least inconvenient itinerary distance in the market. An airline "*HUB_Origin*" zero-one dummy variable equals 1 if the origin airport is a HUB for the ticketing carrier of the product.

Following Berry and Jia (2010), in order to capture potential product characteristics that are unobservable to us due to the relatively high traffic congestion in Florida and Las Vegas, we create a "*Tour*" zero-one dummy variable that equals 1 if the airport is in Florida or Las Vegas. A "*Slot_control*" variable counts the number of slot-controlled airports in a product, which captures the inconvenience of possible longer handling time of air traffic control due to limited airport capacity.[8] In the subsequent sections of the paper we posit that air travel demand is affected by the following variables: *Price* (in thousand dollars), *Interstop*, *Inconvenience*, *HUB_Origin* dummy, *Tour* dummy, *Slot_control*, and ticketing carrier fixed effects.

We posit that air travel supply is affected by the following cost-shifting variables: Itinerary *Distance* (in thousand miles), Itinerary *Distance Squared (noted as* $Distance^2$*)*, *HUB_MC* dummy, *Slot_MC* dummy and operating carrier dummies. "*HUB_MC*" is a zero-one dummy variable that equals 1 if the origin, intermediate stop(s), or destination airport is a HUB

[7] The origin city population is used as the potential market size.

[8] The slot-controlled airports are New York LaGuardia, New York Kennedy, Washington National, and Chicago O'Hare.

for the carrier. "*Slot_MC*" is a zero-one dummy variable that equals 1 if the *Slot_control* variable is greater than zero. Descriptive statistics of the sample data are reported in Table 1.

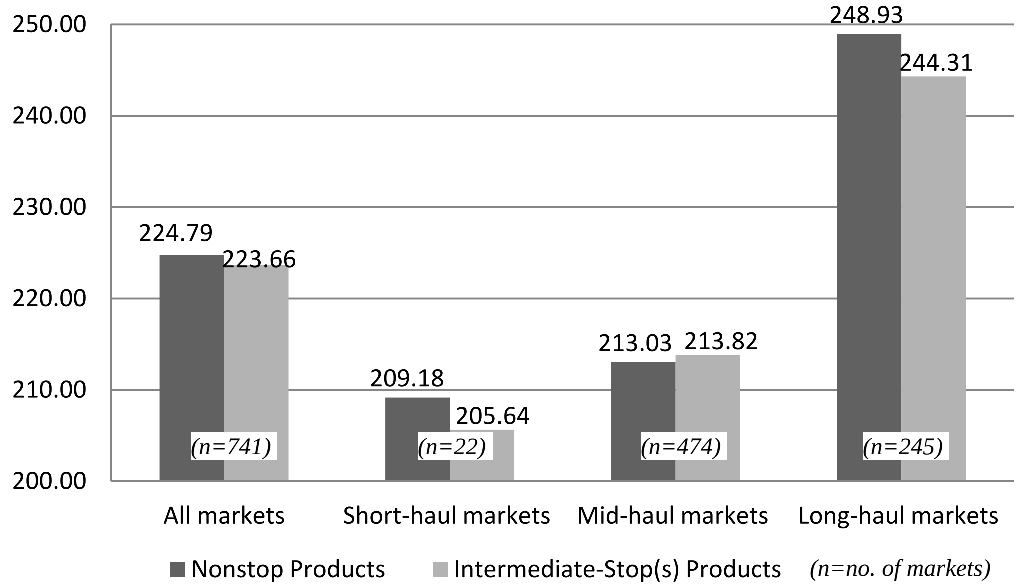
Table 1: Descriptive Statistics

| Variable | Description | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Price | Mean ticket fare for each product, in thousand dollars | 0.2245 | 0.1067 | 0.1033 | 4.553 |
| Quantity | Number of passengers for each product | 187.149 | 542.09 | 5 | 7796 |
| Interstop | Number of intermediate stops | 0.7488 | 0.4587 | 0 | 2 |
| Inconvenience | The ratio of the total itinerary distance to the nonstop flight distance | 1.1465 | 0.2218 | 1 | 2.875 |
| HUB_Origin | Dummy equals 1 if the origin airport is a HUB for the ticketing carrier | 0.1267 | 0.3327 | 0 | 1 |
| Tour | Dummy equals 1 if the airport is in Florida or Las Vegas | 0.1963 | 0.3972 | 0 | 1 |
| Slot_control | Number of slot-controlled airports | 0.2300 | 0.4555 | 0 | 2 |
| Distance | Itinerary flying distance covered on the route used by product, in thousands of miles | 1.6852 | 0.6670 | 0.337 | 3.843 |
| $Distance^2$ | Itinerary flying distance squared | 3.2848 | 2.4164 | 0.114 | 14.769 |
| HUB_MC | Dummy equals 1 if either the origin, the intermediate stop(s), or the destination airport is a HUB for the carrier | 0.4723 | 0.4993 | 0 | 1 |
| Slot_MC | Dummy equals 1 if the Slot_control variable is greater than zero | 0.2148 | 0.4107 | 0 | 1 |
| Observations | 10,883 | | | | |

Overall, across the 741 markets in our sample, the average market fare is about $224.50. Figure 1 illustrates average market fare of nonstop products compared to intermediate-stop(s) products based on flight distance of markets. A short-haul market refers to the nonstop flight distance in a market shorter than 500 miles. The other two market distance categories are the mid-haul market, with the distance between 500 miles and 1,500 miles, and the long-haul market, with the distance longer than 1,500 miles, according to definitions in Gillen et al. (2003).

The average market fare is increasing in distance for both types of products. A comparison of nonstop and intermediate-stop(s) products' prices reveal that a pricing gap between the two product types varies depending on the length of the trip. The average market fare of nonstop products is greater than that of intermediate-stop(s) products in short-haul and long-haul markets. However, in mid-haul markets, the average price ranking is reversed between these two product types. This suggests that competition between these differentiated products may depend on the market nonstop flight distance.

Figure 1: Average Market Fares
for Nonstop vs. Intermediate-Stop(s) Products in 2010:Q1



## 4. The Model

### *4.1 Demand*

Following Berry and Jia (2010) and Berry, Carnal and Spiller (2006),[9] we use a random coefficients discrete choice approach, which allows us to estimate with aggregate market-level data while still being able to identify average choice behavior of different types of consumers. Assume air travel markets are populated with two types of consumers; type 1 consumers which on average is relatively more price-sensitive and have a higher tolerance for less convenient travel itineraries compared to type 2 consumers. Therefore, we may reasonably interpret type 1 consumers to be leisure travelers (subsequently denoted by $L$) and type 2 consumers to be business travelers (subsequently denoted by *B*). But this interpretation of the two consumer types is not "cast in stone".

The indirect utility consumer $i$, who is type $t \in \{L, B\}$, obtain from purchasing product $j$ in market $m$ is given by:

$$u_{ijm} = x_{jm}\beta_t + \alpha_t p_{jm} + \xi_{jm} + \sigma\zeta_{igm} + (1-\sigma)\varepsilon_{ijm} \,, \qquad (1)$$

where $x_{jm}$ is a vector of non-price observable product characteristics,[10] $\beta_t$ is a vector of taste coefficients for $x_{jm}$ for consumers of type $t$, $p_{jm}$ is the product price, $\alpha_t$ is the marginal utility from a change in price for consumers of type $t$, $\xi_{jm}$ captures components of product characteristics that are observed by consumers but unobserved to researchers, $\zeta_{igm}$ is a random component of utility that is common to all products in group $g$, whereas the random term $\varepsilon_{ijm}$ is specific to product $j$. Note that $\mathrm{g} = 0,1,2, \dots, G$ index product groups within a market, and one

[9] Also see Berry (1990).

[10] Based on our previous discussion in the data section, variables in $x_{jm}$ includes: *Interstop*, *Inconvenience*, *HUB_Origin* dummy, *Tour* dummy, *Slot_control*, and ticketing carrier fixed effects.

outside alternative ($g$=0). The outside alternative is the option not to purchase one of the air travel products considered in the model.

Some passengers may view the set of products offered by a given airline to be closer substitutes for each other compared to the substitutability of these products with products offered by other airlines, since a given airline's set of products may share a common desirable characteristic. A passenger may therefore choose to have frequent-flyer membership with a given airline, which serves to reinforce the passenger's loyalty to the set of products offered by that airline. Since we do not have passenger-specific information in the data, such as frequent-flyer membership, one attempt to capture airline brand-loyal choice behavior of consumers is to group products by airline in the demand model. This type of product grouping allows preferences to be correlated across products offered by a given airline. Therefore, product groups that are indexed by g in equation (1) are based on airlines.

The parameter $\sigma$, lying between 0 and 1, measures the correlation of the consumers' utility across products belonging to the same group/airline. If $\sigma = 1$, there is perfect correlation of preferences for products within the same group. On the other hand, there is no correlation of preferences if $\sigma = 0$. Consumer choice behavior is consistent with utility maximization when $\sigma \in (0,1)$ and product shares have the traditional nested logit form.

Let there be $\mathcal{G}_{\mathrm{g}}$ products in group $g$. If product $j$ is in group g, the formula for the within group share of product $j$ among type $t$ consumers in market $m$ is:

$$s_{j|\mathrm{g,m}}^{t}(\mathbf{x},\mathbf{p},\boldsymbol{\xi},\theta) = \frac{\exp\left[(x_{jm}\beta_t+\alpha_t p_{jm}+\xi_{jm})/(1-\sigma)\right]}{D_{\mathrm{gtm}}}, \tag{2}$$

where the denominator in equation (2) is given by:

$$D_{\mathrm{gtm}} = \sum_{j\in\mathcal{G}_{\mathrm{g}}} exp\left[\left(x_{jm}\beta_t + \alpha_t p_{jm} + \xi_{jm}\right)/(1-\sigma)\right]. \tag{3}$$

The share of group $g$ among type $t$ consumers in market $m$ is:

$$s_{\mathrm{gm}}^{t}(\mathbf{x},\mathbf{p},\boldsymbol{\xi},\theta)=\frac{D_{gtm}^{1-\sigma}}{1+\sum_{\mathrm{g}=1}^{G}D_{gtm}^{1-\sigma}}\,. \tag{4}$$

Let $\lambda_t$ be the percentage of type $t$ consumers in the population, where $t \in \{L, B\}$. The overall market share of product $j$ in market $m$ is:

$$s_{jm}(\mathbf{x},\mathbf{p},\boldsymbol{\xi},\theta)=\lambda_L \times s_{j|\mathrm{g,m}}^{L} \times s_{\mathrm{gm}}^{L} + \lambda_B \times s_{j|\mathrm{g,m}}^{B} \times s_{\mathrm{gm}}^{B}\,, \tag{5}$$

where $\lambda_L + \lambda_B = 1$. Note that $\theta$ is the vector of demand parameters to be estimated, which consists of the taste for product characteristics of both consumer types ($\beta_L$ and $\beta_B$), the marginal utility of price of both consumer types ($\alpha_L$ and $\alpha_B$), the correlation of consumers' utility across products belonging to the same group $\sigma$, and the probability of type L consumer $\lambda_L$. $\lambda_B$ is obtained by $\lambda_B = 1 - \lambda_L$.

The demand for product $j$ is given by:

$$D_{jm} = M \times s_{jm}(\mathbf{x},\mathbf{p},\boldsymbol{\xi},\theta)\,, \tag{6}$$

where $M$ is a measure of the market size, which is assumed to be the origin city population in our study.

For comparative purposes we also estimate two more restrictive discrete choice models of demand: (1) the standard logit model; and (2) the simple nested logit model. The simple nested logit model allows consumers' tastes to be correlated across products in the same group but consumers do not differ in their marginal utilities for product characteristics, i.e., consumers are all the same type. The most restrictive of the alternate demand models we consider is the standard logit model, which does not allow consumer taste to be correlated across product groups, nor does the model allow consumers to differ in their marginal utilities for product characteristics.

*4.2 Markups and Marginal Cost*

We assume that carriers simultaneously choose prices as in a static Bertrand-Nash model of differentiated products. Let each carrier *f* offer for sale a set $F_{fm}$ of products in market *m*. Firm *f*'s variable profit in market *m* is given by:

$$\pi_{fm} = \sum_{j \in F_{fm}} (p_{jm} - mc_{jm}) q_{jm} , \tag{7}$$

where $q_{jm} = D_{jm}(\mathbf{p})$ in equilibrium, $q_{jm}$ is the quantity of travel tickets for product *j* sold in market *m*, $D_{jm}(\mathbf{p})$ is the market demand for product *j* in equation (6), **p** is a vector of prices for the *J* products in market *m*, and $mc_{jm}$ is the marginal cost of product *j* in market *m*.

The corresponding first-order conditions are:

$$\sum_{r \in F_{fm}} (p_{rm} - mc_{rm}) \frac{\partial s_r}{\partial p_j} + s_{jm}(\mathbf{x}, \mathbf{p}, \boldsymbol{\xi}, \theta) = 0 \qquad \text{for all } j = 1, \dots, J \tag{8}$$

which can be rewritten in matrix notation as:

$$(\mathbf{p} \quad \mathbf{mc}) \times (\Omega * \Delta) + \mathrm{s}(\mathbf{p}) = 0 , \tag{9}$$

where **p**, **mc**, and $\mathrm{s}(\cdot)$ are $J \times 1$ vectors of product prices, marginal costs, and predicted product shares respectively, while $\Omega * \Delta$ is an element-by-element multiplication of two matrices. $\Delta$ is a $J \times J$ matrix of first-order derivatives of model predicted product market shares with respect to prices, where element $\Delta_{jr} = \frac{\partial s_r(\cdot)}{\partial p_j}$. $\Omega$ is a $J \times J$ matrix which describes carriers' ownership structure of the *J* products. For example, let $\Omega_{jr}$ denote an element in $\Omega$, where

$$\Omega_{jr} = \begin{cases} 1 & \text{if there exist } f: \{j, r\} \subset F_f \\ 0 & \text{otherwise} \end{cases}.$$

That is, $\Omega_{jr} = 1$ if products *j* and *r* are offered for sale by the same carrier, otherwise $\Omega_{jr} = 0$. Based on equation (9), the markup equation can be obtained as:

$$Markup = \mathbf{p} - \mathbf{mc} = -(\Omega * \Delta)^{-1} \times \mathrm{s}(\mathbf{p}) . \tag{10}$$

Finally, the marginal cost equation is specified as:

$$ln(\mathbf{mc}) = \boldsymbol{w}\gamma + \boldsymbol{\eta}\ , \tag{11}$$

where $\boldsymbol{w}$ is a matrix of observed marginal cost-shifting variables,[11] $\gamma$ is a vector of cost parameters to be estimated, and $\boldsymbol{\eta}$ is a vector of cost shocks that is unobserved by researchers. The supply equation implied by equations (10) and (11) is therefore,

$$ln[\mathbf{p} - Markup(\mathbf{x}, \mathbf{p}, \boldsymbol{\xi}, \theta)] = \boldsymbol{w}\gamma + \boldsymbol{\eta}\ . \tag{12}$$

## 5. Estimation

Generalized Method of Moments (GMM) is used to estimate the demand and marginal cost parameters jointly. First we describe how moment conditions are constructed from the demand side of the model, and then describe how other moment conditions are constructed from the supply side of the model.

In case of the demand model, the estimation strategy involves searching for parameter values satisfying the equality between observed product shares ($S_{jm} = \frac{q_{jm}}{M}$) and product shares predicted by the model, $s_{jm}(\mathbf{x}, \mathbf{p}, \boldsymbol{\xi}, \theta)$, that is,

$$S_{jm} = s_{jm}(\mathbf{x}, \mathbf{p}, \boldsymbol{\xi}, \theta), \tag{13}$$

where the right-hand-side of equation (13) is based on the predicted share function in equation (5). To construct moment conditions, we first invert equation (13) to solve for the vector of unobserved product characteristics, $\boldsymbol{\xi}$ , as a function of the observed non-price product characteristics, prices, the observed product shares, and parameters, that is:

$$\boldsymbol{\xi} = s^{-1}(\mathbf{x}, \mathbf{p}, \boldsymbol{S}, \theta). \tag{14}$$

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[11] Based on our previous discussion in the data section, $w_{jm}$ includes: Itinerary *Distance* (in thousand miles), Itinerary *Distance Squared (noted as Distance$^2$)*, *HUB_MC* dummy, *Slot_MC* dummy and operating carrier dummies.

Following Berry and Jia (2010), this inversion is done numerically via the following contraction mapping technique:[12]

$$\boldsymbol{\xi}_{jm}^{k} = \boldsymbol{\xi}_{jm}^{k-1} + (1-\sigma)[ln(\boldsymbol{S}_{jm}) - ln\left(s_{jm}(\mathbf{x}, \mathbf{p}, \boldsymbol{\xi}^{k-1}, \theta)\right)], \qquad (15)$$

where $k$ indexes iterations, $\boldsymbol{S}_{jm}$ is the observed product share, and $s_{jm}(\mathbf{x}, \mathbf{p}, \boldsymbol{\xi}, \theta)$ is the predicted product share function defined by equation (5).

For the simple nested logit model, the unobservable $\boldsymbol{\xi}_{jm}$ is computed analytically using:

$$\boldsymbol{\xi}_{jm} = y_{jm} - [x_{jm}\beta_t + \alpha_t p_{jm} + \sigma ln(\boldsymbol{S}_{j/g})], \qquad (16)$$

where $y_{jm} = ln(\boldsymbol{S}_{jm}) - ln(\boldsymbol{S}_{0m})$, $\boldsymbol{S}_{0m}$ is the observed share of the outside good ($g$=$0$), and $\boldsymbol{S}_{j/g}$ is the observed within group share of product $j$. If we set $\sigma = 0$, equation (16) yields the unobservable for the standard logit model.

Therefore, the demand error term $\boldsymbol{\xi}_{jm}$ from either equation (15) or (16), depending on which demand model is used, yields the following moment conditions:

$$m_d = \frac{1}{n} Z_d' \boldsymbol{\xi}(\mathbf{x}, \mathbf{p}, \boldsymbol{S}, \theta) = 0, \qquad (17)$$

where $n$ is the number of observations in the sample, and $Z_d$ is a $n \times L_d$ matrix of instruments.

The marginal cost error term $\boldsymbol{\eta}$ is obtained from equation (12) as follows:

$$\boldsymbol{\eta} = ln[\mathbf{p} - Markup(\mathbf{x}, \mathbf{p}, \boldsymbol{\xi}, \theta)] - w\gamma, \qquad (18)$$

which is then used to generate the supply-side moment conditions:

$$m_s = \frac{1}{n} Z_s' \boldsymbol{\eta}(\mathbf{w}, \mathbf{p}, Markup, \gamma) = 0. \qquad (19)$$

We combine moment conditions from equations (17) and (19) into a single GMM objective function and jointly estimate parameters in the demand and marginal cost equations. The GMM optimization problem is:

[12] The iteration continues until the maximum difference between $\boldsymbol{\xi}_{jm}^{k}$ and $\boldsymbol{\xi}_{jm}^{k-1}$ is smaller than $10^{-8}$.

$$Min_{\theta,\hat{\gamma}}\left[m\left(\hat{\theta},\hat{\gamma}\right)'Wm(\hat{\theta},\hat{\gamma})\right] \tag{20}$$

where $m\left(\hat{\theta},\hat{\gamma}\right)=\begin{bmatrix}m_d\\ m_s\end{bmatrix}$, and $W$ is the following block diagonal positive definite weight matrix:

$$W=\begin{pmatrix}\left[\frac{1}{n}Z_d'\boldsymbol{\xi}\boldsymbol{\xi}'Z_d\right]^{-1} & \mathbf{0}\\ \mathbf{0} & \left[\frac{1}{n}Z_s'\boldsymbol{\eta}\boldsymbol{\eta}'Z_s\right]^{-1}\end{pmatrix}.$$

Due to the fact that prices and "within" group product shares are endogenous, we need instruments that are associated with these endogenous variables but not with the error terms. Following much of the literature on discrete choice models of demand, we make the admittedly strong identifying assumption that observed non-price product characteristics are uncorrelated with unobserved product quality, $\boldsymbol{\xi}$, or unobserved marginal cost, $\boldsymbol{\eta}$.[13] Similar to Gayle (2011, 2007a, 2007b) and Brown and Gayle (2010), we create the following instruments: (1) the number of substitute products offered by an airline in a market; (2) the number of competitor products in the market; (3) the number of competing products with equivalent number of intermediate stops offered by other carriers; (4) the squared deviation of a product's itinerary distance from the average itinerary distance of competing products offered by other carriers; (5) the sums and averages of the *Inconvenience* and *Interstop* variables;[14] and (6) interactions of these instrument variables.

The instruments are motivated by standard supply theory, which predicts that equilibrium price is affected by the size of markup. In other words, the instruments are assumed to influence the size of an airline's markup on each of its products. For example, a product's markup is constrained by the "closeness" of competing products in characteristics space, which is the rationale for instruments (3) and (4). A product's markup is constrained by the number of

[13] For example, see Berry and Jia (2010) and Peters (2006) for similar identifying assumptions.
[14] See the data section for definition and explanation of the *Inconvenience* and *Interstop* variables.

competing products in the market, which is the rationale for instrument (2). A firm typically can achieve a marginally higher markup on a given product the more substitute products it owns in the market, which is the rationale for instrument (1). Instrument (5) is based on the idea that the average markup that a firm is able to charge is related to the characteristics of its products.

## 6. Results

### *6.1 Parameter Estimates*

Table 2 reports parameter estimates of the demand and marginal cost equations for three alternate demand specifications - standard logit, nested logit and random coefficients logit. We first discuss the demand parameter estimates.

The demand coefficients are consistent in signs and roughly similar in magnitudes across the standard logit and nested logit specifications. These two model estimates essentially capture aggregate choice behavior across consumer types. All coefficients are statistically significant at conventional levels of statistical significance. The negative coefficients for the *Price* and *Interstop* variables suggest that a consumer's utility tends to decrease when the market fare or the number of intermediate stops increase. In other words, consumers most prefer cheap nonstop flights between their origin and destination. [15]

An airline may offer several different single-intermediate stop products in a given market that differ in the location of the intermediate stop and therefore the flying distance required to get to the destination. However, the negative *Inconvenience* coefficient suggests that, for any given

[15] A Hausman test confirms that price and within group product share variables are indeed endogenous at conventional levels of statistical significance. The computed Hausman test statistic, which is chi-square distributed, has a value of 174.51. When the demand model is estimated without instruments the price coefficient is positive and $\sigma$ is almost twice as large, which suggest bias due to endogeneity. As such, we believe that our instruments do a reasonable job in mitigating endogeneity problems.

number of intermediate stops, consumers prefer to take the shortest possible route to get to their destination.

Consistent with documented evidence in the existing literature, the *HUB_Origin* coefficient is positive, which indicates that a carrier is more likely to be chosen by consumers if the origin airport is the carrier's HUB. As such, consumers can exploit the carrier's convenient gate access and superior menu of departure options.[16] As suggested in Berry and Jia (2010), the positive *Tour* dummy coefficient captures the relatively high traffic volume in Florida and Las Vegas that cannot be explained by the observed product attributes. A consumer's utility is likely to decrease if he/she chooses a product passing through a slot-controlled airport, probably owing to longer wait time due to congestion in a slot-controlled airport.

[16] See discussions in Berry, Carnall and Spiller (2006), Berry (1990), Borenstein (1989) and Borenstein (1991).

Table 2: Joint Estimation of Demand and Marginal Cost Equations

| ***Demand Equation*** | Standard Logit | | Nested Logit | | Random Coefficients Logit | |
|---|---|---|---|---|---|---|
| Variable | coeff. | Se | coeff. | se | coeff. | se |
| **Both Types of Consumers** | | | | | | |
| Price | -9.707* | (0.717) | -9.690* | (0.768) | | |
| Interstop | -1.625* | (0.050) | -1.393* | (0.055) | | |
| Constant | -7.047* | (0.182) | -7.206* | (0.190) | | |
| **Type L Consumers** | | | | | | |
| Price | | | | | -11.562* | (1.132) |
| Interstop | | | | | -1.304* | (0.129) |
| Constant | | | | | -5.861* | (0.170) |
| **Type B Consumers** | | | | | | |
| Price | | | | | -1.456* | (0.211) |
| Interstop | | | | | -1.404* | (0.145) |
| Constant | | | | | -9.055* | (0.186) |
| Inconvenience | -0.914* | (0.075) | -0.774* | (0.076) | -0.997* | (0.019) |
| HUB_Origin | 0.807* | (0.068) | 1.063* | (0.071) | 0.961* | (0.097) |
| Tour | 1.435* | (0.040) | 1.480* | (0.039) | 1.580* | (0.104) |
| Slot-control | -0.590* | (0.043) | -0.556* | (0.042) | -0.583* | (0.058) |
| AirTran | 1.440* | (0.148) | 1.379* | (0.144) | 1.376* | (0.255) |
| Alaska | 3.685* | (0.709) | 3.701* | (0.719) | 1.930* | (0.267) |
| Allegiant | 2.454* | (0.466) | 2.449* | (0.481) | 3.291* | (1.650) |
| American | 1.559* | (0.156) | 1.566* | (0.153) | 1.329* | (0.144) |
| JetBlue | 2.158* | (0.175) | 2.241* | (0.171) | 2.104* | (0.681) |
| Continental | 1.186* | (0.159) | 1.127* | (0.157) | 0.877* | (0.072) |
| Delta | 1.401* | (0.149) | 1.502* | (0.146) | 1.309* | (0.072) |
| Frontier | 1.274* | (0.164) | 1.107* | (0.163) | 1.055+ | (0.550) |
| Northwest | 0.583* | (0.154) | 0.558* | (0.152) | 0.432+ | (0.241) |
| Southwest | 1.265* | (0.141) | 1.481* | (0.139) | 1.432* | (0.135) |
| Spirit | 1.348* | (0.249) | 1.223* | (0.249) | 0.164+ | (0.085) |
| Sun Country | 1.710* | (0.417) | 1.589* | (0.416) | 1.463* | (0.215) |
| United | 1.390* | (0.152) | 1.448* | (0.149) | 1.218* | (0.111) |
| US Airways | 1.606* | (0.156) | 1.645* | (0.153) | 1.395* | (0.222) |
| USA 3000 | 1.415* | (0.493) | 1.401* | (0.485) | 1.154* | (0.403) |
| Virgin America | 2.219* | (0.246) | 2.280* | (0.242) | 2.034* | (0.848) |
| $\sigma$ | | | 0.170* | (0.020) | 0.209* | (0.008) |
| $\lambda_L$ | | | | | 0.318* | (0.034) |

* represents significant at the 0.05 level. + represents significant at the 0.10 level. Standard errors are in parentheses. Midwest Airlines is the excluded ticketing carrier dummy.

Table 2: Joint Estimation of Demand and Marginal Cost Equations *(Continued)*

| ***Marginal Cost Eq.*** | Standard Logit | | Nested Logit | | Random Coefficients Logit | |
|---|---|---|---|---|---|---|
| Variable | coeff. | Se | coeff. | se | coeff. | se |
| Constant | -2.772* | (0.102) | -2.774* | (0.102) | -3.099* | (0.082) |
| Distance | 0.273* | (0.045) | 0.274* | (0.046) | 0.376* | (0.046) |
| Distance$^2$ | -0.009 | (0.013) | -0.009 | (0.013) | -0.063* | (0.011) |
| HUB_MC | 0.129* | (0.016) | 0.129* | (0.016) | 0.117* | (0.023) |
| Slot_MC | 0.090* | (0.014) | 0.090* | (0.014) | 0.037* | (0.014) |
| | | | | | | |
| GMM objective | 2.78E+03 | | 2.52E+03 | | 2.47E+04 | |
| Number of obs. | 10883 | | 10883 | | 10883 | |

* represents significance at the 0.05 level. $^{+}$ represents significance at the 0.10 level. Standard errors are in parentheses. The marginal cost equation includes operating carrier dummies even though these are not reported in the table.

As expected, the parameter $\sigma$ lies between 0 and 1, which measures the correlation of the consumers' utility across products belonging to the same airline. The value of $\sigma$ is 0.17 and suggests that there is correlation of preferences for products belonging to a given airline, but this correlation does not seem to be economically strong since the correlation value is substantially less than 1.

Recall that the random coefficients logit model allows us to disentangle choice behavior for two types of consumers. Parameter estimates for the random coefficients logit demand model are reported in the rightmost panel of Table 2. The coefficients are all statistically significant at conventional levels of significance. The price coefficients suggest that type L consumers (leisure travelers) are much more sensitive to price changes compared to type B consumers (business travelers). Therefore, the evidence suggests that the two types of consumers view a product differently with respect to their marginal utilities of price.

The value of $\sigma$ still shows some correlation of preferences for products belonging to a given airline. The estimate of $\lambda_L$ is 0.318, indicating 32 percent of type L consumers in the population.

As to the marginal cost equation in Table 2, the coefficients are consistent in signs and roughly similar in magnitudes irrespective of the demand model specification. The sign pattern of the coefficients on *Distance* and *Distance*$^2$ suggests that marginal cost increases with distance up to some threshold distance, but declines in distance thereafter. The positive *HUB_MC* and *Slot_MC* coefficients suggest that an increase in the marginal cost occurs if an airport on the product itinerary is the carrier's HUB or a slot-controlled airport. When a carrier passes through the slot-controlled airport, the cost is higher possibly due to higher landing fees. Channeling passengers through the airline's hub normally allows the airline to better exploit economies of density since passengers from different origins and with different destinations can eventually be put on a single large plane for a segment of the trip. This should have a downward pressure on marginal cost.[17] However, as suggested by arguments in Borenstein and Rose (2007) and Mayer and Sinai (2003), often time hub airports are congested, which could cause flight delays and ultimately puts an upward pressure on cost for the airline.[18] Therefore, the coefficient on *HUB_MC* captures the net effect of these opposing forces, and possibly others.

### *6.2 Own Price Elasticity of Demand*

Using the parameter estimates in Table 2, we compute average own- and cross-price elasticities of demand, but first we discuss the own-price elasticity estimates. Own-price elasticity measures the percentage change in demand for an air travel product in response to a

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[17] See Berry, Carnall and Spiller (2006) and Brueckner and Spiller (1994).

[18] For a detailed analysis of the theory of congestion and delays, see Brueckner (2002) and Morrison and Winston (2008).

percentage change in price of that product. Table 3 reports summary statistics for own-price elasticity estimates for the three alternate demand model specifications.

The upper panel of Table 3 shows results for all products in 741 markets, and also the results for nonstop and intermediate-stop(s) products separately. The own-price elasticity estimates across the three demand models are statistically different from zero at conventional levels of significance. Our own-price elasticity estimates for the average consumer range from -1.67 to -2.39 depending on the discrete choice demand model used. Oum, Gillen and Noble (1986), and Brander and Zhang (1990) argue that a reasonable range for own price elasticity in the airline industry is from -1.2 to -2.0. Peters (2006) study of the airline industry produces own-price elasticity estimates ranging from -3.2 to -3.6, while Berry and Jia (2010) find own-price elasticity estimates ranging from -1.89 to -2.10 in their 2006 sample. Therefore, we are comfortable that the elasticity estimates generated from our model are reasonable and accord with evidence in the existing literature.

Table 3: Summary Statistics for Own-Price Elasticity Estimates across all Markets in our Sample

| | All Products | | Nonstop Products | | Intermediate-stop(s) Products | |
|---|---|---|---|---|---|---|
| Demand Model | Mean | se | Mean | se | Mean | se |
| Standard Logit | -2.169* | (0.018) | -2.175* | (0.022) | -2.171* | (0.025) |
| Nested Logit | -2.390* | (0.021) | -2.291* | (0.023) | -2.443* | (0.030) |
| Random Coefficients Logit | | | | | | |
| Both Types | -1.675* | (0.004) | -1.554* | (0.004) | -1.731* | (0.005) |
| Type L Consumer | -2.929* | (0.025) | -2.779* | (0.028) | -3.010* | (0.037) |
| Type B Consumer | -0.368* | (0.003) | -0.349* | (0.003) | -0.379* | (0.005) |
| No. of markets | 741 | | 741 | | 741 | |

| | Short-haul markets (less than 500 miles) | | Mid-haul markets (between 500 and 1,500 miles) | | Long-haul markets (greater than 1,500 miles) | |
|---|---|---|---|---|---|---|
| Demand Model | Mean | se | Mean | se | Mean | se |
| Standard Logit | -1.994* | (0.128) | -2.067* | (0.023) | -2.381* | (0.028) |
| Nested Logit | -2.154* | (0.133) | -2.260* | (0.025) | -2.662* | (0.031) |
| Random Coefficients Logit | | | | | | |
| Both Types | -1.571* | (0.018) | -1.648* | (0.004) | -1.735* | (0.005) |
| Type L Consumer | -2.625* | (0.161) | -2.764* | (0.030) | -3.277* | (0.039) |
| Type B Consumer | -0.330* | (0.020) | -0.348* | (0.004) | -0.412* | (0.005) |
| No. of markets | 22 | | 474 | | 245 | |

* represents significant at the 0.05 level. Standard errors are in parentheses.

The elasticity estimates in the upper panel of Table 3 indicate that consumers are sensitive to a price change, irrespective of whether the product is nonstop or requires intermediate stop(s). However, in the case of the nested logit and random coefficients logit models, the average consumer responds differently when facing a price change of a nonstop product compared to an equivalent percent price change of an intermediate-stop(s) product. Specifically, it is noticeable that the average consumer is more price-sensitive in the case of intermediate-stop(s) products compared to nonstop products.

Elasticity estimates from the random coefficients logit model indicate that leisure travelers (Type L) are much more price-sensitive compared to business travelers (Type B). Overall, a 1% increase in price causes leisure travelers to decrease their demand for the product by 2.93%, while business travelers would only decrease their demand by 0.37%. Leisure travelers are likely more sensitive to price changes because they have more flexibility in their travel schedule and usually have a more restrictive travel budget. The price-sensitivity gap between leisure and business travelers is even wider in the case of intermediate-stop(s) products (-3.01 versus -0.379) compared to the price-sensitivity gap for nonstop products (-2.779 versus -0.349).

In the bottom panel of the table we decompose the own-price elasticity estimates according to market nonstop flight distance categories. The average own-price elasticity seems to be increasing in distance, which is consistent with findings in Bhadra (2003). In other words, consumers are less price-sensitive in short-haul markets compared to long-haul markets. It is possible that many of the passengers who travel short distance are business travelers. They likely purchase flight tickets at the last moment and have little or no chance to respond to price changes.

### *6.3 Cross Price Elasticity of Demand*

Cross price elasticity measures the percentage change in demand for intermediate-stop(s) products in response to a percentage change in price of nonstop products. Summary statistics for cross-price elasticity estimates across all markets are reported in Table 4.

Table 4: Summary Statistics for Cross-Price Elasticity Estimates across all Markets in our Sample

| Demand Model | Mean | Se |
|---|---|---|
| Standard Logit | 0.00018* | (1.05E-05) |
| Nested Logit | 0.01321* | (0.0004) |
| Random Coefficients Logit | | |
| Both Types | 0.01258* | (0.0004) |
| Type L Consumer | 0.02023* | (0.0007) |
| Type B Consumer | 0.00257* | (8.93E-05) |
| No. of markets | 741 | |

* represents significant at the 0.05 level. Standard errors are in parentheses.

Overall, across the 741 markets in our sample, the positive and statistically significant cross-price elasticity of demand estimates indicate that intermediate-stop(s) products and nonstop products are substitutes. The result from each demand model shows that the mean cross-elasticity ranges from 0.00018 to 0.0202, and they are statistically different from zero at conventional levels of significance.

Compared to business travelers, leisure travelers perceive intermediate-stop(s) products and nonstop products as closer substitutes. A 1% increase in the price of nonstop products causes leisure travelers to increase their demand for intermediate-stop(s) products by 0.0202%, but only causes business travelers to increase their demand for intermediate-stop(s) products by 0.0026%.[19] In other words, leisure travelers are more willing than business travelers to switch to intermediate-stop(s) products when facing an increase in price of nonstop products, suggesting that leisure travelers are more willing to tolerate intermediate stops compared to business travelers.

[19] A t-test is used here to confirm that at conventional levels of statistical significance there is a statistically significant difference in mean cross-price elasticity between leisure travelers and business travelers. The difference in mean cross-price elasticities (0.0202 - 0.0026) is 0.0176 and the standard error of the difference is 0.000686, which implies a t-statistic of 25.65.

Table 5 breaks down the cross-price elasticity estimates by market nonstop flight distance. Within each distance category, the results show that the mean cross-price elasticities are statistically different from zero at conventional levels of significance. These results suggest that consumers perceive intermediate-stop(s) products and nonstop products as substitutable in all distance categories of air travel markets.

Table 5: Summary Statistics for Cross-Price Elasticity Estimates
Broken Down by Market Nonstop Flight Distance

| | Short-haul markets (less than 500 miles) | | Mid-haul markets (between 500 and 1,500 miles) | | Long-haul markets (greater than 1,500 miles) | |
|---|---|---|---|---|---|---|
| Demand Model | Mean | se | Mean | se | Mean | se |
| Standard Logit | 0.00008* | (1.67E-05) | 0.00021* | (1.52E-05) | 0.00015* | (1.13E-05) |
| Nested Logit | 0.00787* | (0.0019) | 0.01375* | (0.0006) | 0.01263* | (0.0007) |
| Random Coefficients Logit | | | | | | |
| Both Types | 0.00851* | (0.0021) | 0.01366* | (0.0006) | 0.01085* | (0.0005) |
| Type L Consumer | 0.01144* | (0.0028) | 0.02108* | (0.0009) | 0.01937* | (0.0010) |
| Type B Consumer | 0.00167* | (0.0004) | 0.00267* | (0.0001) | 0.00246* | (0.0001) |
| No. of markets | 22 | | 474 | | 245 | |

* represents significant at the 0.05 level. Standard errors are in parentheses.

Irrespective of whether the market is short-haul, mid-haul, or long-haul, leisure travelers are more willing to switch to intermediate-stop(s) products compared to business travelers in response to an increasing price of nonstop products. Again, it is evident that leisure travelers are more flexible to change their travel schedule in response to price changes.

It is notable that consumers in the short-haul markets are less willing to switch to an intermediate-stop(s) product in response to an increase in price of a nonstop product. In addition, the average cross-price elasticity increases from short-haul market to mid-haul market, but decrease a bit from mid-haul market to long-haul market.

Table 6 reports statistical comparisons of mean cross-price elasticity estimates across different market distances. The results suggest that there is a statistically significant difference in mean cross-price elasticity between short-haul and mid-haul markets. However, when separate consumer types are accounted for, there is not a significant mean difference between mid-haul and long-haul markets.

Table 6: Statistical Comparison of Mean Difference in Cross-price Elasticity between Distance Markets

| Distance Market Comparison | Standard Logit | Nested Logit | Random Coefficients Logit: Both types | Random Coefficients Logit: Type L Consumers | Random Coefficients Logit: Type B Consumers |
|---|---|---|---|---|---|
| Mid- vs. Short-haul | 0.00013* | 0.00589* | 0.00515* | 0.00965* | 0.00100* |
| | (2.3E-05) | (0.0020) | (0.0022) | (0.0030) | (0.0004) |
| Long- vs. Mid-haul | -0.00006* | -0.00112 | -0.00281* | -0.00172 | -0.00021 |
| | (1.9E-05) | (0.0009) | (0.0008) | (0.0014) | (0.0002) |
| Long- vs. Short-haul | 0.00007* | 0.00476* | 0.00234 | 0.00793* | $0.00079^{+}$ |
| | (2.0E-05) | (0.0020) | (0.0022) | (0.0030) | (0.0004) |

* represents significant at the 0.05 level. $^{+}$ represents significant at the 0.10 level. Standard errors are in parentheses.

It may be argued that the distance categories used in the previous tables are arbitrary. As such, using an approach that is more flexible than the distance categories, we investigate a potential relationship between computed elasticities and the nonstop market distance. In particular, we estimate the following regression via ordinary least squares (OLS):

$$Y_i = \alpha_0 + \alpha_1 Dist_i + \alpha_2 Dist_i^2 + \varepsilon_i,$$

where $Y_i$ is the cross-price elasticity in market *i*, which is regressed on the market nonstop flight distance (*Dist*) and distance squared ($Dist^2$). Table 7 shows the results of the OLS regression.

Table 7: Parameter Estimates for the Relationship Between Cross-price Elasticities and Market Nonstop Distance

| | Standard Logit | Nested Logit | Random Coefficients Logit: Both type Consumers | Random Coefficients Logit: Type L Consumers | Random Coefficients Logit: Type B Consumers |
|---|---|---|---|---|---|
| Dist | 3.23E-07* | 7.54E-06+ | 5.34E-06 | 1.24E-05* | 1.23E-06 |
| | (9.41E-08) | (4.05E-06) | (3.76E-06) | (6.13E-06) | (8.06E-07) |
| $Dist^2$ | -1.13E-10* | -2.62E-09* | -2.38E-09+ | -4.25E-09* | -4.35E-10+ |
| | (3.08E-11) | (1.33E-09) | (1.23E-09) | (2.01E-09) | (2.64E-10) |
| Constant | -9.61E-06 | 8.72E-03* | 1.05E-02* | 1.27E-02* | 1.85E-03* |
| | (6.31E-05) | (2.72E-03) | (2.52E-03) | (4.11E-03) | (5.40E-04) |
| Threshold point | 1434 | 1438 | 1122 | 1456 | 1417 |
| R-squared | 0.0186 | 0.0055 | 0.0133 | 0.0061 | 0.0039 |

* represents significant at the 0.05 level. + represents significant at the 0.10 level. Standard errors are in parentheses. The distance threshold point is computed by, $Dist\ threshold = -\frac{\alpha_1}{2\alpha_2}$.

The parameter estimates suggest that cross-price elasticity is increasing with distance between the origin and destination cities up to some threshold distance, but decline in distance thereafter. The range of the estimated distance threshold point is between 1122 and 1456 miles, depending on the demand model used to generate the cross-price elasticity estimates. These results are roughly consistent with the arbitrary distance category analysis done previously.

### *6.4 Markup and Marginal Cost Analysis*

The parameter estimates in the demand equation allows us to compute markups and marginal costs, which are summarized in Table 8.

Table 8: Summary Statistics for Markup and Marginal Cost (in Dollars)

| | Standard Logit | | Nested Logit | | RC Logit | |
|---|---|---|---|---|---|---|
| | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev |
| **Markup** | | | | | | |
| All products | 103.215 | 0.321 | 103.336 | 0.230 | 151.867 | 32.249 |
| Nonstop products | 103.345 | 0.602 | 103.365 | 0.304 | 155.581 | 40.775 |
| Intermediate-stop(s) products | 103.162 | 0.226 | 103.324 | 0.211 | 150.450 | 34.051 |
| **Marginal Cost** | | | | | | |
| All products | 120.476 | 51.883 | 120.356 | 51.875 | 71.825 | 28.370 |
| Nonstop products | 121.441 | 62.280 | 121.422 | 62.257 | 69.205 | 33.639 |
| Intermediate-stop(s) products | 120.494 | 69.975 | 120.331 | 69.972 | 73.205 | 50.084 |

Based on the standard logit and nested logit models, on average, nonstop and intermediate-stop(s) products have markups that are roughly similar in size. However, the random coefficients logit model suggests that, on average, a nonstop product enjoys larger markup (about 5 dollars more) than an intermediate-stop(s) product, which is more consistent with our expectations. Based on our previous results on own-price elasticity of demand, we believe that price-sensitive consumers are more likely to buy intermediate-stop(s) products compared to nonstop products. In addition, standard static oligopoly theory tells us that the more price-sensitive consumers are, the lower the markup firms are able to charge. Thus, the markups under the random coefficient logit model better reflect the differing choice behavior of dissimilar consumer types across nonstop and intermediate-stop(s) products.

As we previously discussed in the subsection on own-price elasticities, our own-price elasticity estimates are within the range of those obtained by other researchers [see for example Berry and Jia (2010), Brander and Zhang (1990), Oum, Gillen and Noble (1986), and Peters (2006)]. Since standard static oligopoly theory predicts that product markups are determined by price elasticity of demand, then product markups generated by our model will be similar to product markups implied by the elasticity estimates of other researchers.

Recall that observed prices minus estimated markups yield estimates of marginal costs. Therefore it is not surprising that the larger average markup from the random coefficients logit model results in smaller average marginal cost, compared to results from the other two models. In addition, the random coefficients logit model yields the result that average marginal cost of nonstop products is less than that of intermediate-stop(s) products.

The mean itinerary distance for products in our sample is 1685 miles, while the mean marginal cost estimates from the standard, nested, and random coefficients logit models are $120.48, 120.36 and $71.82 respectively. Therefore, the implied marginal cost per mile is about 7 cents in case of the standard and nested logit models, and about 4 cents in case of the random coefficients logit model. Berry and Jia (2010) estimate their econometric model on data in the year 2006 and find a marginal cost per mile estimate of 6 cents, which they argue is plausible based on carriers' reported costs. As such, we believe our marginal cost estimates are within the "ballpark" of what is expected.

### *6.5 Counterfactual Analysis*

The goal of the counterfactual analysis is to assess the extent to which the presence of intermediate-stop(s) products influences the pricing of nonstop products. In other words, do intermediate-stop(s) products effectively compete with nonstop products, or can they be treated as being in separate market segments?

Essentially the counterfactual experiment is done by removing intermediate-stop(s) products from each sample market, then assuming the previously estimated product marginal costs and preference parameters are unchanged, we use the supply-side of the model to solve for new equilibrium prices for nonstop products. A comparison of the actual nonstop products' prices with their model predicted equilibrium prices when intermediate-stop(s) products are counterfactually removed reveals the extent to which the presence of intermediate-stop(s) products influences the pricing of nonstop products.

Formally, in the spirit of Petrin (2002), Nevo (2000) and others, we first use estimated markups, actual prices and equation (10) to recover product marginal costs as follows:

$$\widehat{\mathbf{mc}} = \mathbf{p} + (\Omega * \Delta)^{-1} \times s(\mathbf{p}), \qquad (21)$$

where $\widehat{\mathbf{mc}}$ is the estimated marginal cost vector. Second, we eliminate intermediate-stop(s) products, and holding recovered marginal cost constant for the remaining products, we numerically solve for the new nonstop product price vector, $\mathbf{p}^*_{\mathbf{ns}}$, that satisfies:

$$\mathbf{p}^*_{\mathbf{ns}} = \widehat{\mathbf{mc}}_{\mathbf{ns}} - [\boldsymbol{\Omega}_{\mathbf{ns}} * \boldsymbol{\Delta}_{\mathbf{ns}}(\mathbf{p}^*_{\mathbf{ns}})]^{-1} \times \mathbf{s}_{\mathbf{ns}}(\mathbf{p}^*_{\mathbf{ns}}), \qquad (22)$$

where equation (22) is only for nonstop products. Finally, we compare the counterfactual equilibrium price vector $\mathbf{p}^*_{\mathbf{ns}}$ to actual nonstop product prices in vector $\mathbf{p}$ to see the influence that intermediate-stop(s) products may have on the equilibrium prices of nonstop products.

Before we examine the results of the counterfactual exercise, it is useful to discuss what forces are at play in the market equilibrium analysis. In other words, do we expect equilibrium prices of nonstop products to fall, rise, or remain the same when intermediate-stop(s) products are counterfactually removed, and what does the predicted price change depend on? We argue that there are potentially three effects simultaneously at work that may influence the predicted equilibrium price change of nonstop products: (1) the market power effect; (2) the multi-product firm effect; and (3) the price-sensitivity effect.

The most intuitive of the three effects is the market power effect. This effect simply refers to the increased ability and incentive of carriers to raise the price of the remaining products if competing substitute products are removed from the market.

The multi-product firm effect refers to the situation in which, if the product that is removed from the market is one of several substitute products offered by a firm, then this firm has an incentive to marginally reduce the price on its remaining products. In the appendix we use a linear demand example to illustrate this effect. The intuition is that a multi-product firm selling substitute products tends to price these products marginal higher than if it were a single-product firm because a marginal increase in the price of one product raises the demand for the substitute products.

The price-sensitivity effect refers to the situation in which there is downward pressure on the price of a product when the price-sensitivity of consumers increases. This effect is likely to exist in our counterfactual exercise since our previous results show that intermediate-stop(s) products tend to be consumed by more price-sensitive consumers compared to the consumers of nonstop products. Therefore, by removing the intermediate-stop(s) products from the market, we in effect force carriers to optimally adjust the price of nonstop products for a more price-sensitive set of consumers that do not have any other air travel product options. This will put a downward pressure on the price of nonstop products.

In summary, by counterfactually removing intermediate-stop(s) products from the market, the market power effect puts an upward pressure on the price of nonstop products, while the multi-product firm and price-sensitivity effects cause downward pressure on price. Thus, what ultimately happens to the price of nonstop products depends on which effects dominate.

Table 9 summarizes one way of examining the counterfactual results. In particular, among the nonstop products in the sample, the table reports the number and proportion of these products with positive predicted percentage change in their equilibrium price. These results are broken down by whether or not the nonstop products were offered by carriers that also offered substitute intermediate-stop(s) products in the same market, i.e., single-product versus multi-product carriers.

First, we focus our discussion on results in the table for the standard logit and nested logit models. Interestingly, for these two models, there is a predicted increase in price for all 777 nonstop products offered by carriers that only offer a single product in the market before and after intermediate-stop(s) products are removed. The multi-product firm effect is not present for these 777 nonstop products since they are offered by single-product carriers. However, we cannot rule out the presence of both the market power and price-sensitivity effects. If both effects are present, then we must conclude that the market power effect dominates the price-sensitivity effect for these products. On the other hand, among the 2078 nonstop products that are offered by carriers that also offered intermediate-stop(s) products, few nonstop product prices are predicted to increase. The majority of these nonstop product prices are predicted to either remain the same or fall. The market power effect is obviously dominated by either or both of the other two effects for the majority of these products.

Table 9: Number and Proportion of Nonstop-products with Positive Predicted Percentage change in Equilibrium Price for Single-product and Multi-product carriers in a Market

| | | Standard Logit | | Nested Logit | | RC Logit | |
|---|---|---|---|---|---|---|---|
| | No. of Products | No. of Products with Positive % Change | Proportion of Products with Positive % Change | No. of Products with Positive % Change | Proportion of Products with Positive % Change | No. of Products with Positive % Change | Proportion of Products with Positive % Change |
| Single-product carrier | 777 | 777 | 1.00 | 777 | 1.00 | 52 | 0.0669 |
| Multi-product carrier | 2078 | 13 | 0.0063 | 4 | 0.0019 | 202 | 0.0972 |

Now turning to results from the random coefficients model in Table 9, we see that even in the case of single-product carriers in a market, only 52 of the 777 nonstop products offered by single-product carriers are predicted to experience an increase in price. Since the multi-product firm effect is not present for these products, we know that the lack of many predicted price increases is owing to the domination of the price-sensitivity effect over the market power effect. The evidence suggests that the random coefficients model does a better job of picking up the price-sensitivity effect compared to the standard logit and nested logit models. In addition, among the 2078 nonstop products offered by multi-product carriers, the random coefficients logit model predicts that only a few (202) are predicted to have price increases. Again, the market power effect is clearly dominated by either or both of the other two effects for the majority of these products.

We now examine results of the counterfactual exercise in terms of actual predicted percent price changes for nonstop products, rather than mere direction of the predicted price changes previously discussed. Results for actual predicted price changes are reported in Table 10. The results reveal that for the vast majority of markets, there is a mean percent decline in the prices of nonstop products, with overall predicted mean percent declines of -0.0009%, -0.0083%

and -0.125%, from the standard, nested, and random coefficients logit models respectively. The predicted declines seem to be largest in mid-haul distance markets.

The bottom right-hand-side panel of the table shows that only 2 of the 741 markets have mean predicted percent price increase greater than 5%, and only 1 market has mean predicted percent price decrease less than -5%. In addition, the 2 markets that have mean predicted percent price increases are long-haul distance markets. In summary, with the exception of 2 long-haul distance markets, all markets have mean predicted price changes for nonstop products being less than 5%.

In defining relevant product markets for antitrust purposes, 5% predicted change in price is typically used as an economically important threshold.[20] Since the counterfactual results suggest that the presence of intermediate-stop(s) products typically have a less than 5%, and in most cases less than 1%, impact on the price of nonstop products, then we may conclude that for antitrust purposes nonstop and intermediate-stop(s) air travel products can be treated as being in separate product markets.

[20] For example, see Section 4.1 in U.S. Department of Justice and Federal Trade Commission (2010), “Horizontal Merger Guidelines”.

Table 10: Nonstop-products Predicted Percent Price Change
for Different Market Distance Categories

Standard Logit Model

| Distance Type | No. of Markets | Mean | Std. Dev | Min | Max | No. of Markets with Positive % Change |
|---|---|---|---|---|---|---|
| All markets | 741 | -0.0091 | 0.0172 | -0.2083 | 0.0006 | 13 |
| Short-haul markets | 22 | -0.0030 | 0.0045 | -0.0160 | 3.63E-08 | 1 |
| mid-haul markets | 474 | -0.0101 | 0.0197 | -0.2083 | 0.0006 | 12 |
| long-haul markets | 245 | -0.0076 | 0.0113 | -0.0795 | -4.80E-06 | 0 |

Nested Logit Model

| Distance Type | No. of Markets | Mean | Std. Dev | Min | Max | No. of Markets with Positive % Change |
|---|---|---|---|---|---|---|
| All markets | 741 | -0.0083 | 0.0162 | -0.1954 | 0.0002 | 13 |
| Short-haul markets | 22 | -0.0026 | 0.0040 | -0.0135 | 1.82E-08 | 1 |
| mid-haul markets | 474 | -0.0093 | 0.0187 | -0.1954 | 0.0002 | 12 |
| long-haul markets | 245 | -0.0069 | 0.0106 | -0.0781 | -3.99E-06 | 0 |

Random Coefficients Logit Model

| Distance Type | No. of Markets | Mean | Std. Dev | Min | Max | No. of Markets that lie within the Percent Change category | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | >0% | >5% | <-5% |
| All markets | 741 | -0.1254 | 0.8464 | -6.8557 | 5.2747 | 76 | 2 | 1 |
| Short-haul markets | 22 | -0.0628 | 0.1212 | -0.5521 | 0.0014 | 2 | 0 | 0 |
| mid-haul markets | 474 | -0.1926 | 0.5898 | -6.8557 | 4.6205 | 21 | 0 | 1 |
| long-haul markets | 245 | -0.0011 | 1.2135 | -2.7893 | 5.2747 | 53 | 2 | 0 |

## 7. Conclusion

The main objective of the paper is to investigate the extent to which nonstop products are substitutable with intermediate-stop(s) products. Cross-price elasticity of demand estimates suggest that, on average, consumers perceive intermediate-stop(s) products substitutable for nonstop products. In addition, the average cross-price elasticity increases from short-haul distance to mid-haul distance markets, but decreases a bit from mid-haul distance to long-haul distance markets. Consumers in short-haul distance markets are less willing to switch to an intermediate-stop(s) product in response to an increase in price of a nonstop product. The results also suggest that intermediate-stop(s) products may be an attractive alternative for leisure travelers but less so for business travelers, regardless of the length of market distance.

We then conduct a counterfactual exercise to better understand the extent to which the presence of intermediate-stop(s) products influences the pricing of nonstop products. By removing intermediate-stop(s) products from each market, we identified three effects that may simultaneously influence the pricing of nonstop products: (1) a market power effect; (2) a multi-product firm effect; and (3) a price-sensitivity effect. The market power effect puts an upward pressure on the price of nonstop products, while the multi-product firm and price-sensitivity effects cause downward pressure on price. Therefore, the net change in price of nonstop products that results from eliminating intermediate-stop(s) products depends on which of the three effects dominate. We find that in the vast majority of markets the prices of nonstop products are predicted to either remain the same or fall, which suggest that the market power effect is often offset by the multi-product firm and price-sensitivity effects. Furthermore, the vast majority of the predicted price changes lie between -1% and 1%. The evidence therefore suggests that the presence of intermediate-stop(s) products in most markets have little net impact on the price of nonstop products. As such, for antitrust purposes, these two products can be treated as being in separate product markets.

The findings in this paper have important implications for analyzing proposed mergers. For example, a merger between one carrier that serves a market exclusively with nonstop products and one that serves the market exclusively with intermediate-stop(s) products is not likely to enhance market power substantially. By the same token, two carriers that currently serve a market using nonstop service and are seeking approval to merge will be hard pressed to make a convincing argument that the existence of intermediate-stop(s) service offered by competing carriers will effectively constrain the newly merged firm from exercising market power.

The focus of our analysis is on domestic air travel markets. However, antitrust analysis and approval of international airline alliances often requires answering the very question we tackle in this paper. Since consumers may display different choice behavior in international air travel markets than they do in domestic markets, future research may want to investigate if our findings extend to international air travel markets.

## Appendix

The following example is used to illustrate the multi-product firm effect assuming linear demand and constant marginal cost.

Assume an airline is a multi-product monopolist who offers differentiated products 1 and 2 in an origin-destination market, where product 1 is a nonstop product while product 2 is an intermediate-stop(s) product. The products' linear demand equations are:

$$q_1 = 1 + \beta p_2 - p_1 \,;\; q_2 = 1 + \beta p_1 - p_2$$

where $0 < \beta < 1$. For simplicity, assume each product has the same constant marginal cost, $c$. The variable profit for the airline is:

$$\pi = (p_1 - c)[1 + \beta p_2 - p_1] + (p_2 - c)[1 + \beta p_1 - p_2]$$

The corresponding first-order conditions are:

$$c(1 - \beta) - 2p_1 + 2\beta p_2 + 1 = 0\,;$$

$$c(1-\beta) - 2p_2 + \beta p_1 + 1 = 0$$

Thus, the equilibrium prices for products 1 and 2 are:

$$p_1^* = p_2^* = \frac{1}{2(1-\beta)} + \frac{c}{2}$$

Now suppose we counterfactually eliminate the intermediate-stop(s) product, which is product 2. In other words, the airline becomes a single-product monopolist who only offers nonstop products 1 in the market. The product's linear demand equation is:

$$q_1 = 1 - p_1.$$

With the assumption of constant marginal cost, *c*, the variable profit is:

$$\pi = (p_1 - c)[1 - p_1]$$

The corresponding first-order condition is:

$$c - 2p_1 + 1 = 0$$

Thus, the monopoly price is:

$$p_1^M = \frac{1}{2} + \frac{c}{2}$$

Comparing the price of product 1 before and after the counterfactual exercise, we can see that $p_1^M < p_1^*$, which indicates that the price of product 1 decreases if product 2 is removed. Therefore, this example illustrates that, *ceteris paribus*, there exists a downward pressure on price for the remaining products of a multi-product firm when one of the firm's substitute products is removed from the market.

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