Prices, Profits, and Entry Decisions:
The Effect of Southwest Airlines

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Abstract

In this paper, I examine how Southwest Airlines—the largest low-cost carrier (LCC) by far—influences the pricing, profits, and entry decisions of its competitors. While much of the literature on Southwest only examines nonstop flights, I extend this body of scholarship to incorporate connecting flights using various methods and data. First, I assume that the entry of Southwest and the market structures are exogenous. Using a set of fixed effects models, I find that incumbent legacy carriers cut both connecting and nonstop prices when Southwest starts to operate on a route. Moreover, price drops are much larger for connecting flights than for nonstop flights. Second, I relax the exogeneity assumptions and allow entry and market structures to be endogenous. By estimating a static game of simultaneous entry, I find that Southwest has a very strong, negative impact on the payoff functions of its competitors. This impact is firm-specific. When I break the entry down by product types, I find that the entry of a low-quality product affects opponents’ profits less than the entry of a high-quality product does. If facing the same type of entry, the profit of a low-quality product is more seriously affected than that of a high-quality product. In this instance, a low-quality product is a connecting service and a high-quality product is a nonstop service. Finally, by conducting counterfactual experiments, I find that Southwest has a substantial impact on the entry decision of each competitor and on the equilibrium number of non-Southwest firms in the market.
1 Introduction

Southwest Airlines is the largest low-cost carrier (LLC) by far, worldwide. Over the past few decades, its continued expansion has become a principal driving force behind the growth of LCCs, the drop of airfares, and the structural changes in the U.S. airline industry. Unlike major carriers, which utilize a hub-and-spoke network and operate with a variety of different aircrafts, Southwest operates within a point-to-point network and uses only the Boeing 737\(^1\). This allows Southwest to operate at low costs and, at the same time, implement considerable flexibility in the routes it flies. Financial reports have shown that Southwest has substantially lower unit costs than other major carriers. According to Form 10-K, the operating cost per ASM (available seat mile) for Southwest was $0.125 in 2014, while for major airlines it was, at least, $0.1342. Table 8 in Appendix A provides a breakdown of operating costs on an ASM basis for major carriers and Southwest.

Southwest’s low-cost strategy has proved to be extremely successful. It is not surprising that Southwest has attracted a growing amount of empirical attention within the industrial organization literature. A great deal of research has been conducted to demonstrate its dramatic downward pressure on airfares, including Dresner et al. (1996), Morrison (2001), and Goolsbee and Syverson (2008).

However, most existing studies on Southwest only examine nonstop flights. Economists have studied how the fares for the incumbents’ nonstop flights change when Southwest starts, or threatens to start, operating nonstop flights on the same routes. But the airline industry is more than nonstop flights. Connecting flights comprise a majority of all air travel. In fact, according to the 2010 Airline Origin and Destination Survey (DB1B) data, the share of domestic passengers that traveled with nonstop service, one-stop service, and two-stop service are 39%, 57%, and 4%, respectively. The share of passengers traveled with connecting service is even higher on less popular routes. For example, on routes with less than 25,000 passengers per year, the share of nonstop travelers and one-stop travelers are, respectively, 27% and 70%.

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\(^{1}\)“Southwest Airlines – Details and Fleet History – Planespotters.net Just Aviation”.
It should be noted that although Southwest is famous for the art of point-to-point (P2P) routing, it provides connecting service as well, only not to the same degree as the traditional legacy carriers, like Delta and American. For instance, in 2010, Southwest provided connecting service on 1223 domestic routes, and provided nonstop service on 690 routes, while for Delta the numbers of routes were 1625 and 610 for connecting and nonstop service respectively.\(^2\)

Given that connecting trips are very common and make up a large portion of the airline industry, excluding them from research will lead to incomplete, or sometimes even biased, results. The first contribution of this paper is to fill this gap. In doing, I first study how Southwest influences the pricing of both types of services (nonstop and connecting). Based on more than 10 years of panel data, I regress prices on a set of time dummies around Southwest’s entry into the market, while controlling for several fixed effects, including market-carrier-pair fixed effects, time fixed effects, and airport fixed effects. The results show that incumbent legacy carriers cut both connecting and nonstop prices upon Southwest’s entry. Moreover, price drops are much larger for connecting flights than for nonstop flights. This is rational behavior. Due to the inconvenience of connecting flights, incumbents perceive the need to cut their prices more to remain attractive to customers.

In the above analysis, the entry of Southwest and the market structures are assumed to be exogenous. Nonetheless, these assumptions may not hold. An entry decision is clearly an endogenous decision that an individual firm makes after comparing costs and benefits. Market structure is also an endogenous outcome because it is a combination of each firm’s entry decision. These endogeneities really should be modeled and accounted for.

For this reason, I estimate a game of simultaneous entry where firms’ decisions to enter a market are based on whether they will realize non-negative profit from entry. At this point, cross-sectional data is used. I assume that each airline takes its overall network structure as a given when deciding whether or not to operate in a market. An airline’s post-entry profit in a market is specified as a function of market-level variables, of its own airport presence and fixed costs, and of the competitive effects occasioned by its competitors. The parameters in determining profit functions

\(^2\) The numbers of routes are identified from the 2010 DB1B data.
are then estimated such that the entry outcomes, predicted by the model, are consistent with the empirical entry outcomes, obtained from the data. The existence of multiple equilibria constitutes a big challenge in estimating this kind of model. For example, consider a market where there are three potential entrants: one large and two small. The possible market structure could be one where the large firm has a monopoly, but it could also be a duopoly of the two smaller firms. To deal with multiplicity, I use the simulation method proposed by Ciliberto and Tamer (2009). The main concept of their approach is that although the probability of a particular outcome in multiple equilibria cannot be calculated, the probabilities of each outcome can still be bounded. So the goal is to bound the observed probabilities of different outcomes within the lower and upper bounds predicted by the model. The simulation is necessary, because it is nearly impossible to calculate, analytically or numerically, the mass for which the model predicts each equilibrium outcome.

I first aggregate data across different product types. Results show that Southwest has a very strong negative impact on the payoff functions of its competitors. Moreover, this impact is firm-specific. The profits of medium airlines and small LCCs are more significantly influenced than those of larger airlines. Among the large airlines, Delta is influenced the most. After that, I break the entry down by product types. There are two types of product: connecting service, which is a low-quality product, and nonstop service which is a high-quality product. I find that the entry of the low-quality product affects competitors’ profits less than the entry of the high-quality product. If facing the same type of entry, the profit of the low-quality product is more seriously affected than that of the high-quality product.

Using the estimated parameters discussed above, I perform counterfactual experiments to assess the extent to which Southwest’s entry influences the entry of other airlines. The counterfactuals are conducted by setting the competitive effects of Southwest equal to zero and then recomputing the new equilibria. I find that removing Southwest increases the probability of observing each individual carrier. For example, the probability of American in the market increases by as much as 54.5% when Southwest is removed, while the probability of observing small LCCs increases by up to 59.6%. Moreover, the equilibrium number of non-Southwest airlines in the market increases. These results suggest that Southwest has a substantial impact on the entry decision of each competitor and on the total number of non-Southwest firms in the market.
The findings of this paper provide a comprehensive picture of Southwest’s effect on various aspects of the U.S. market for air travel. They expand the empirical literature in a number of key ways. To the best of my knowledge, this paper is the first to confirm that Southwest’s entry leads to a decrease in incumbents’ connecting fares using price variation within a route. It is also the first to evaluate the effect of Southwest’s presence on each individual carrier’s profit based on a partial identification approach. Moreover, it adds to the literature on multiproduct entry by examining two types of products: a high-quality product which is the nonstop service and a low-quality product which is the connecting service. Finally, the counterfactual experiments carried out in this study are unique.

The remaining portion of this manuscript is organized as follows. Section 2 discusses the related literature. Section 3 describes the data and the steps taken to construct samples. Section 4 estimates the effect of Southwest’s entry on airfares. Section 5 examines the effect of Southwest’s entry on other airlines’ profit functions. Section 6 presents counterfactual exercises to evaluate how Southwest influences the entry decision of each competitor and the equilibrium number of firms in the market. Concluding remarks are made in Section 7.

2 Related Literature

This paper is related to three streams of literature: literature on the Southwest effect, literature on connecting flights, and literature on empirical entry games.

2.1 Literature on the Southwest Effect

A great deal of attention in the economic literature has been devoted to the salutary impact of Southwest’s entry on airfares and demand for air transportation, otherwise known as the “Southwest effect”. As early as 1993, Bennett and Craun concluded that Southwest’s operations on the Oakland-Burbank route resulted in a 55% decrease in prices as well as a six-fold increase
in passenger traffic. Later researches found similar results by studying different routes and different settings, including Richards (1996), Dresner et al. (1996), and Morrison (2001). Recently, economists have started to examine what happens to prices before Southwest entry. Goolsbee and Syverson (2008) revealed that incumbents do, in fact, cut prices prior to Southwest’s entry, which counters the classic view that preemptive price-cutting is irrational.

However, most of these studies only examine nonstop trips. Given that connecting trips are so common in the airline industry, ignoring them is not a wise option, because it may lead to incomplete or, sometimes, even biased results. One of the contributions of this paper is to incorporate an examination of connecting flights so as to extend empirical research to provide a more comprehensive picture of the airline industry.

### 2.2 Literature on Connecting Flights

Reiss and Spiller (1989) initiated the analysis of modeling nonstop and connecting services into a single model. Their analysis suggests that the type of service is an important determinant of the level of competition in the airline market. Though Reiss and Spiller discuss only those small airline markets where one firm, at most, offers nonstop service, their conclusion that nonstop and connecting products are imperfect substitutes is very constructive.

Other works that discuss connecting flights include Lijesen et al. (2002), Dunn (2008), Berry and Jia (2010), Gayle and Wu (2011), and Brueckner et al. (2013). This paper differs from these prior studies in two key aspects. The first aspect is airfares: unlike the previous works that examine fare variation across routes, I estimate fare changes within a route. The second aspect is entry: I allow asymmetric competitive effects between airlines and between product types, which has rarely been carried out in the preceding literature.
2.3 Literature on Empirical Entry Games

Bresnahan and Reiss (1990) originated the empirical analysis of entry games. The existence of multiple equilibria constitutes a big challenge to estimating entry. To deal with this problem, Bresnahan and Reiss make the assumption that firms are identical. They find that while which firms enter is not unique, the number of firms that enter is unique. Berry (1992) extended the original model to allow for heterogeneity in firms’ fixed costs, but still assumes homogeneity in firms’ competitive effects. The equilibrium condition is that all firms entering are profitable and all firms that choose not to enter expect to have had zero or negative profits had they entered. Under these conditions, Berry shows that the equilibrium number of entrants is unique. Ciliberto and Tamer (2009) further extended the model to allow for asymmetric competition effects. In their setting, the equilibrium number of entrants was no longer unique, such that the region of multiplicity may have become very large. Ciliberto and Tamer proposed that, although it is not possible to calculate the probability of a particular outcome without resolving the multiplicity issue, it is possible to bound the probabilities of each outcome. They then provided a simulation approach, where the bounds are estimated. I replicate Ciliberto and Tamer’s method in this analysis because their model allows for a very general profit function specification, so that asymmetric competition effects between airlines and between product types can be estimated.

Other scholarship that estimates entry games includes Mazzeo (2002) and Bajari, Hong, and Ryan (2005). In the area of incomplete information, literature includes Seim (2006) and Sweeting (2009).

3 Data

3.1 Data Construction

The primary data employed in this study’s analyses came from the Airline Origin and Destination Survey (DB1B), published by the U.S. Bureau of Transportation Statistics. The DB1B provides a 10% random sample of all domestic tickets. The database includes: (i) identifying information for ticketing, operating, and reporting carriers associated with each ticket; (ii) the ticket fare and the
number of passengers that purchase each ticket; (iii) origin and destination airports as well as the sequence of any intermediate airport stop that each trip may use; (iv) total flight distance; and (v) the nonstop flight distance between the origin and destination airports. The database does not contain any passenger-specific information such as: (i) whether the passenger holds frequent-flyer membership with an airline; (ii) whether the purpose of the trip is business or leisure; (iii) the date of the ticket purchase; (iv) how far in advance of the travel date the ticket was purchased; (v) how long the layover is for connecting trips; etc.

Data in this study are focused on U.S. domestic flights, offered and operated by U.S. carriers. I impose the following data restrictions. I drop: (i) trips that are part of international travel; (ii) trips that have two 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 a final destination; (iii) trips with fares of less than $20 because of the high probability that these may be data entry coding errors or discounted trips that are rare instances; and (iv) trips with a change in the ticketing carrier or the operating carrier.

Note that the dataset used to estimate price changes (Sample-A) is different from the dataset used to estimate entry game (Sample-B). Table 1 presents a summary of these two datasets.

Sample-A includes data from the first quarter of 1993, through to the last quarter of 2010. It is panel data that contains detailed trip information such as: the origin and destination airports, the ticket carriers, the number of passengers that purchased each type of ticket, the total flight distance, the nonstop flight distance, the ticket prices and the number of intermediate stops.

Sample-B includes data in the first quarter of 2010. I further merge Sample-B with demographic information on population and income from the U.S. Census Bureau for all the metropolitan statistical areas (MSAs) in the U.S.. In total, the merged Sample-B is cross-sectional data that contains trip information as well as demographic information (e.g., population, per capita income, and income growth rate of the origin and destination MSAs).
3.2 Market Definition

Following Borenstein (1989), Goolsbee and Syverson (2008), and Ciliberto and Tamer (2009), I define a market as the trip between two airports, irrespective of intermediate transfer points and the direction of the flight. If a city has multiple airports, I assume that flights to different airports in the same city are in separate markets.

3.3 Market Selection

In order for a market to remain in the sample, I require that at least 90 passengers traveled between the two endpoints (for a predicted quarterly traffic of 900). This corresponds to a once-a-week flight by a medium-size jet.

In Sample-A, I further restrict the sample to markets where Southwest started flying between 1993 and 2010. In order to be identified as an instance of actual entry, Southwest must not have operated in the market for 12 quarters prior to the quarter of entry and must remain in the market for at least four successive quarters. Southwest must have also transported, either with or without stops, at least 20 passengers in the quarter of entry.

In Sample-B, I include all markets that transported at least 90 passengers in the sample period. I also include some markets that were, temporarily, not served by any carrier, which are the markets where the number of observed entrants is equal to zero. To select these markets, I first construct a ranking of airports by the metropolitan statistical areas (MSAs) population. I then identify unserved markets between the top 50 MSAs and add them to the sample.

In total, Sample-A includes 656 markets, and Sample-B includes 2850 markets.
3.4 Data Aggregation

I aggregate data by ticketing carrier. In Sample-A, the data is aggregated into market-carrier-quarter-product type cells. For example, “JFK-ATL-Delta-2010Q1-onestop”, where “JFK-ATL” is the market, “Delta” is the carrier, “2010Q1” is the quarter, and “onestop” is the type of product. Average logged ticket prices and the logged total number of passengers within each cell are then computed.

In Sample-B, the data is aggregated into market-carrier cells. For example, the above observation should belong to the cell “JFK-ATL-Delta”.

3.5 Carrier Definition

A firm is defined as serving a market if it transports at least 20 passengers in one quarter (for a predicted quarterly traffic of 200), either with or without stops.

In Sample-A, I further restrict my attention to the seven legacy carriers operating during the sample period: American, Delta, US Airways, United, Continental, Northwest, and TWA.

In Sample-B, I include all available carriers. For a particular carrier $i$, I construct a categorical variable $y_i$ that is equal to 1 if the carrier serves the market, regardless of the product type, and equal to 0 if it does not serve the market. The reason for doing this is because Sample-B is used to analyze entry game, where I am only interested in knowing whether a carrier serves a market or not. After constructing the categorical variables, the relevant unit of observation is market specific.

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3 In one specification (Table 4 in Section 5), I aggregate data into market-carrier-product type cells.
4 In one specification (Table 4 in Section 5), I break down the presence of firms by product types. For a particular firm $i$, there are two dummy variables indicating its presence: $y_{i, connect}^*$ is equal to 1 if firm $i$ operates connecting flights in the market and is equal to 0 otherwise; $y_{i, nonstop}^*$ is equal to 1 if firm $i$ operates nonstop flights in the market and is equal to 0 otherwise.
In addition to building categorical variables for Southwest, American, Delta, US Airways, and United individually, I construct two more categorical variables that indicate the types of the remaining firms. The categorical variable $y_{MA}$ is equal to 1 if either Continental or Alaska Airlines is present in a specific market.\(^5\) I call them “medium airlines”. The categorical variable $y_{LCC}$ is equal to 1 if at least one of the small low-cost carriers is present in a specific market. Small LCCs include AirTran Airways, Allegiant, Frontier, Spirit, JetBlue, Virgin, and Sun Country Airlines.

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\(^5\) Note that Northwest and TWA are merged with other airlines and no longer exist as independent carriers in the sample period of Sample-B.
4 How Does Southwest Influence Airfares?

In this section, I assume that Southwest’s entry and the market structures are exogenous. Recall that in order to be identified as an instance of actual entry, Southwest must not have operated in the market for 12 quarters prior to the quarter of entry and must remain in the market for at least four successive quarters. Southwest must have also transported, either with or without stops, at least 20 passengers in the quarter of entry.

4.1 Empirical Specification

I use a set of fixed effects models to identify the effect of Southwest’s entry on incumbents’ prices. Two dependent variables are used, namely, the logged mean fare of nonstop trips ($lnp_{nonstop}$), and the logged mean fare of connecting trips ($lnp_{connecting}$). Table 9 in Appendix A provides complete descriptive statistics for the dependent variables.

I control for several fixed effects. I include market-carrier-pair fixed effects to control for unobserved differences across market-carrier-pairs. I also include time fixed effects to control for any changes over time. Lastly, I add airport fixed effects to control for any unobserved differences across airports.

The empirical specification is as follows:

$$y_{ijt} = \gamma_{ij} + \mu_t + o_i + d_l + \sum_{\tau=-8}^{9} \beta_{\tau} entry_{i,j,t+\tau} + a ln(1 + quality_{ijt}) + \epsilon_{ijt} \quad (1)$$

where $y_{ijt}$ is either $lnp_{nonstop}_{ijt}$ or $lnp_{connecting}_{ijt}$ for incumbent carrier $i$ on market $j$ in quarter $t$; $\gamma_{ij}$ is market-carrier fixed effects; $\mu_t$ is time fixed effects; $o_i$ is origin airport fixed effects; and $d_l$ is destination airport fixed effects$^6$.

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$^6$ Recall that the markets are defined irrespective of the direction of the flight. Thus, the use of the terms “origin” and “destination” refers to either one of the market endpoints.
entry\textsubscript{\textit{j,t}_0+\tau} are the time dummies that specify the lag/forward of Southwest’s entry into a market. There are 18 time dummies that account for eight quarters before entry to infinite quarters after entry, including the actual quarter of entry. In particular, entry\textsubscript{\textit{j,t}_0-8} is equal to one if the observation occurred eight quarters before Southwest entered market \textit{j}, entry\textsubscript{\textit{j,t}_0-7} is equal to one if the observation occurred seven quarters before Southwest entered market \textit{j}, etc. entry\textsubscript{\textit{j,t}_0} indicates the quarter in which Southwest entered market \textit{j}. entry\textsubscript{\textit{j,t}_0+1} indicates the first quarter after Southwest entered market \textit{j}, ..., entry\textsubscript{\textit{j,t}_0+8} indicates the eighth quarter after Southwest entered market \textit{j}. Finally, entry\textsubscript{\textit{j,t}_0+9} indicates the ninth to infinite quarters after Southwest entered market \textit{j}.

quality\textsubscript{\textit{ijt}} measures the quality of the trip. Following Dunn (2008), I calculate the quality of a connecting trip as the total distance flown on the connecting flight minus the nonstop distance between the two endpoint airports. As this variable decreases, the quality of connecting service raises. For nonstop trips, this variable is zero.

The coefficients of interest are \( \beta_\tau \). Note that I omit dummy variables for the ninth to infinite quarters preceding the quarter in which Southwest entered. So my estimated \( \beta_\tau \) should show the relative sizes of the dependent variable in the dummy period compared with its value in the excluded period.

In all regressions, I weight observations by the number of passengers flying the market-carrier combination in the quarter, so larger incumbent routes have a greater impact on the measured average response than smaller routes. I also cluster the standard errors by market-carrier-pair, to account for correlation between a market-carrier combination over time.
4.2 Empirical Results

Table 10 in Appendix A summarizes the results from estimating model (1) using Sample-A. In the table, column (I) shows the results when dependent variable is \( \text{lnp\_nonstop} \), and column (II) shows the results when dependent variable is \( \text{lnp\_connecting} \).

Since the dummies are mutually exclusive, the entry coefficients are not additive. In order to track the price changes of incumbents, I graph price paths based on the estimates of time dummy coefficients. I transform the estimates in order to interpret the coefficients as relative percent changes in price. The term “relative” can be interpreted as being relative to prices in the excluded period. Entry occurs at time 0, with negative time values signifying quarters before entry and positive time values signifying quarters after entry. The solid line is the transformation of the point estimates from the model. The dotted lines represent the 95% confidence interval. If prices are constant throughout, then this can be considered as the incumbents’ not responding to entry with any sort of price changes. If prices are less than zero and are statistically significant before entry, this provides evidence for preemptive price-cutting.

Figure 1 illustrates the price paths for incumbents in response to Southwest’s entry. Figure 1(a) shows the changes of nonstop prices and Figure 1(b) shows the changes of connecting prices.

According to Figure 1(a), incumbents cut their average nonstop prices before Southwest actually enters the route. By the quarter prior to Southwest’s entry (period \( t_0 - 1 \)), incumbents set the nonstop prices to be 3.9% lower,\(^7\) on average, relative to the excluded period (the ninth to infinite quarters before entry). One reason to explain preemptive price-cutting is that incumbents resort to using it to signal to customers that they too are low-cost and subsequently deter entry. The average price further decreases to 6.2% lower in the quarter of entry (period \( t_0 \)). In this case, an immediate price drop because of Southwest’s entry should be 2.3% (=6.2%-3.9%). The average price continues to fall in the first and second quarter after entry. From the third quarter after entry, prices start to rise slightly. By the eighth quarter after entry (period \( t_0 - 8 \)), the average price is down by

\(^7\) The percent change relative to the excluded period is found by \( \exp(-0.064) - 1 \approx -0.062 \).
5.4%. These results corroborate previous findings in the literature, specifically that incumbents decrease their nonstop prices in response to entry by Southwest Airlines.

In addition, I want to further determine whether this effect also holds true for connecting services. Figure 1(b) answers this question. It shows that incumbents tend to cut their average connecting price preemptively as well, but not to the same degree as they do for nonstop prices. Here, the preemptive price drop is 1.9% (period $t_0 - 1$). Prices further decrease to 6% lower in the quarter that Southwest enters (period $t_0$). Hence, the immediate price drop due to Southwest’s entry should be 4.1% ($=6\%-1.9\%$), which is much larger than the immediate drop in the case of nonstop prices. In subsequent time periods, prices continue to fall. By the eighth quarter after entry (period $t_0 - 8$), the average price is down by 8.3%. Based on the 95% confidence intervals (the dotted lines), the price drops are statistically significant.

The results suggest that it is worthwhile to examine the variations of both nonstop and connecting fares. Incumbents cut connecting prices more because connecting flights are less competitive when competing with new entrants due to their inconvenience. Thus, carriers have to cut these fares more to compensate consumers.
5 How Does Southwest Influence Profits?

In this section, I relax the assumptions of exogeneity and allow entry and market structures to be endogenous. Indeed, entry is clearly an endogenous decision that an individual firm makes after comparing costs and benefits. Market structure is also an endogenous outcome because it is a combination of each individual firm’s entry decision. In this instance, market structure means the number of firms that serve the market and the identities of these firms.

To model endogeneity, I estimate a static game of simultaneous entry. I assume that an airline will enter a market as long as it can realize non-negative profit from entry. An airline’s post-entry profit in a market is specified as a function of market-level variables, of its own airport presence and fixed costs, and of the competitive effects brought by its competitors. The parameters in determining profit functions are then estimated such that the entry outcomes, predicted by the model, are consistent with the empirical entry outcomes, obtained from the data.

Note that the estimation is based on the assumptions that each airline takes its overall network structure as a given when deciding whether to enter a market, and airlines make decisions independently.

5.1 Empirical Specification

Firstly, I aggregate across nonstop and connecting service, in accordance with Ciliberto and Tamer (2009). The profit function for firm \( i \) in market \( m \) is:

\[
\pi_{im} = S_m' \alpha_i + Z_{im}' \beta + \sum_{j \neq i} \delta_j \ y_{jm} + u_{im}
\]  

(2)

where \( S_m \) is a vector of market characteristics which are common among all firms in market \( m \); \( Z_{im} \) is a vector of firm characteristics which enter only into firm \( i \)’s profit in market \( m \); \( y_{-im} \) is a vector that represents other potential entrants in market \( m \); finally, \( u_{im} \) is the part of profits that is unobserved by the econometrician.
I allow the market-level control variables to have different effects on the profits of firms. That is to say, $\alpha_i \neq \alpha_j$.

The coefficients of interest are $\{\delta^i_j\}$. They summarize the effect of entry by other firms on the profit of firm $i$. I call this their competitive effect. Notice that the effect on firm $i$’s profit of having firm $j$ in its market is allowed to be different from that of having firm $k$ in its market, i.e., $\delta^i_j \neq \delta^i_k$. For example, the effect of United’s presence on American’s profit is given by $\delta^{AA}_{UA}$, while the effect of Delta’s presence on American’s profit is given by $\delta^{AA}_{DL}$. The effects on the profits of different firms of having firm $k$ in the market is also allowed to be different, i.e., $\delta^i_k \neq \delta^i_j$. For example, the effect of Southwest’s presence on American’s profit is given by $\delta^{AA}_{WN}$, while the effect of Southwest’s presence on United’s profit is given by $\delta^{UA}_{WN}$.

Next, I break down firms’ entry by product types. The profit function for firm $i$’s product of type $\varphi$ in market $m$ is given by:

$$
\pi_{im}^{\varphi} = S_m^\prime \alpha_i + Z_{im}^\prime \beta + \delta_{i,-\varphi}^i y_{im}^{\varphi} + \sum_{j \neq i} \delta_{j,\varphi}^i y_{jm}^{\varphi} + \sum_{j \neq i} \delta_{j,-\varphi}^i y_{jm}^{\varphi} + u_{im}^{\varphi}
$$

There are only two types of products: a high-quality product, which is the nonstop service, and a low-quality product, which is the connecting service. If $\varphi$ represents the nonstop product, then $-\varphi$ represents the connecting product, and vice versa. $\delta_{i,-\varphi}^i$ captures the effect of the presence of firm $i$’s type $-\varphi$ product on the profit of its type $\varphi$ product; $\delta_{j,\varphi}^i$ measures the effect of the presence of firm $j$’s type $\varphi$ product on the profit of firm $i$’s type $\varphi$ product; and $\delta_{j,-\varphi}^i$ measures the effect of the presence of firm $j$’s type $-\varphi$ product on the profit of firm $i$’s type $\varphi$ product.

### 5.2 Variable Definitions

I now define the variables used in this study. Table 2 gives a summary of these variables.
The market characteristics included in $S_m$ are:

- **Market size**: The geometric mean of the city population at the market endpoints.\(^8\)
- **Per capita income**: The average per capita income of the cities at the market endpoints.
- **Income growth rate**: The average rate of per capita income growth of the cities at the market endpoints.
- **Market distance**: The nonstop distance between the endpoints.\(^9\)
- **Closest airport**: The distance from each airport to the closest alternative airport.\(^10\) Notice that for each market, there are two of these distances because there are two endpoints. The variable is equal to the minimum of these two distances.
- **Slot**: A zero-one dummy that equals 1 if either one of the market endpoints is a slot-controlled airport. The slot-controlled airports are New York LaGuardia, New York Kennedy, Ronald Reagan Washington, and Chicago O’Hare.

The dummy variables included in $y_m$ are:

- For a particular firm $i$, $y_{im}$ is equal to 1 if firm $i$ serves market $m$, regardless of the product type, and equal to 0 if it does not serve the market.
- I build dummy variables for Southwest, American, Delta, US Airways, and United individually, i.e., $y_{WNm}$, $y_{AAm}$, $y_{DLm}$, $y_{USm}$, and $y_{UAm}$.
- I then construct two more dummy variables that indicate the types of the remaining firms. The dummy variable $y_{MAm}$ is equal to 1 if either Continental or Alaska Airlines is present in market $m$. I call them “medium airlines”. The dummy variable $y_{LCCm}$ is equal to 1 if at least one of the small low-cost carriers is present in market $m$. Small LCCs include AirTran Airways, Allegiant, Frontier, Spirit, JetBlue, Virgin, and Sun Country Airlines.
- In Section 5.6, I break down firms’ entry by product types. Then for a particular firm $i$, there are two dummy variables indicating its presence: $y_{im}^{\text{connect}}$ is equal to 1 if firm $i$ operates connecting flights in market $m$ and equal to 0 otherwise; $y_{im}^{\text{nonstop}}$ is equal to 1 if firm $i$ operates nonstop flights in market $m$ and equal to 0 otherwise.

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\(^8\) Data for population and income are acquired from the U.S. Census Bureau.

\(^9\) Data for nonstop distances are extracted from DB1B.

\(^10\) Data on the distances between airports are from the National Transportation Atlas Database, available from the Bureau of Transportation Statistics. They are also used to construct the variable $cost$. 
The firm characteristics included in $Z_{im}$ are:

- **Airport Presence**: A carrier’s airport presence on a market is the average of its airport presence at the two endpoints. The calculation of the variable *airport presence* proceeds as follows. For each airline and each market, I first compute the ratio of markets served by the airline out of an endpoint airport over the total number of markets served out of that airport by at least one carrier. Then I repeat the same computation for the other endpoint and take the average. For example, when I consider Delta and the market between Columbus and New York Kennedy, I proceed as follows. If Delta serves 20 out of Columbus’ 50 markets, then Delta’s airport presence at Columbus is $20/50 = 40\%$. It is possible to perform the same calculation for New York Kennedy. I begin by assuming that Delta’s airport presence at New York Kennedy is 30\%. Then for the market between Columbus and New York Kennedy, Delta’s airport presence is $(40\% + 30\%)/2 = 35\%$.  

- **Cost**: Following Ciliberto and Tamer (2009), I measure cost as the ratio of the minimum connecting distance that the airline must travel in excess of the nonstop distance over the nonstop distance between the two endpoints. In detail, the calculation of cost proceeds as follows. Firstly I ascertain the nonstop distance between a market’s endpoints. Then I compute the sum of the geographical distances between a market’s endpoints and the closest hub of a carrier. Next, I compute the difference between the sum and the nonstop distance, and divide this difference by the nonstop distance.  

The variable *cost* measures the opportunity fixed cost of serving a market. It is an opportunity cost because it measures the cost of the next best alternative to a nonstop service, which is a connecting flight through the closest hub. It is associated with the fixed cost because it is a fixed number that does not depend on the number of passengers transported by a particular carrier. Although Southwest and a few other low-cost carriers do not use major hubs in the same sense as legacy 

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11 The construction of the variable airport presence requires some additional steps when it comes to types of firms. When I consider the medium airlines (MA), I first compute the airport presence for Continental and Alaska Airlines, and then I take the maximum of the two. When I consider the small low-cost carriers (LCC), I first compute the airport presence of each of the low-cost carriers, and then I take their maximum again.

12 The construction of variable cost requires some additional steps when it comes to types of firms. When I consider the medium airlines (MA), I take the minimum among the distances that I compute for Continental and Alaska Airlines. When I consider the small low-cost carriers (LCC), I take the minimum, again, among the distances that I compute for each of the low-cost carriers.
carriers, they do have focus airports where they have a meaningful presence and offer connecting services. A list of the hubs and focus airports used in this paper is given in Appendix B.

<table>
<thead>
<tr>
<th>Table 2: Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Airport presence</td>
</tr>
<tr>
<td>AA</td>
</tr>
<tr>
<td>DL</td>
</tr>
<tr>
<td>US</td>
</tr>
<tr>
<td>UA</td>
</tr>
<tr>
<td>WN</td>
</tr>
<tr>
<td>MA</td>
</tr>
<tr>
<td>LCC</td>
</tr>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>AA</td>
</tr>
<tr>
<td>DL</td>
</tr>
<tr>
<td>US</td>
</tr>
<tr>
<td>UA</td>
</tr>
<tr>
<td>WN</td>
</tr>
<tr>
<td>MA</td>
</tr>
<tr>
<td>LCC</td>
</tr>
<tr>
<td>Market size</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Per capita income ($)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Income growth rate (%)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Market distance (miles)</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Closest airport (miles)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Slot (0/1)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>N of markets</td>
</tr>
</tbody>
</table>

Note: In this table, “WN” represents Southwest.
5.3 Simulation

Parameters in the profit function are estimated using the simulation method proposed by Ciliberto and Tamer (2009). The main concept of this approach is to find the set of parameter values such that the probabilities of different outcomes, obtained from the data, are bounded within the lower and upper bounds predicted by the model. In this instance, an equilibrium outcome $y = (y_1, y_2, ..., y_K)$ is a sequence of zeroes and ones (e.g., American and Southwest are on the market, but no one else is).

Simulation is necessary because calculating, analytically or numerically, the mass for which the model predicts each equilibrium outcome is nearly impossible, particularly as the number of firms grows and the dimensions of the error term distribution grows.

The detailed simulation procedure is provided in Appendix C.

5.4 Reporting of Estimates

In Tables 3 and 4, I report the cube that contains the confidence region, which is defined as the set that contains the parameters that cannot be rejected as the truth, $\theta = (\alpha, \beta, \delta)$, with at least 95% probability.\(^\text{13}\) Since, generically, these models are not point identified and since the true parameters, along with all the parameters in the identified set, minimize a nonlinear objective function, it is not possible to provide estimates of the bounds on the true parameter.\(^\text{14}\) However, my reported cubes have the coverage property and can be used as consistent estimators for the bounds of the partially identified parameter $\theta$.

\(^\text{13}\) Not every parameter in the cube belongs to the confidence region. This region can contain holes, but here I report the smallest connected “cube” that contains the confidence region.

\(^\text{14}\) The reason is that it is not possible to solve for the upper and lower endpoints of the bounds.
5.5 Empirical Results: Aggregate Across Product Types

Table 3 provides the results for estimating model (2) using Sample-B. Here, I aggregate data across different product types. There are two types of products: a high-quality product, which is the nonstop service, and a low-quality product, which is the connecting service. A firm is defined as serving a market if it transported at least 20 passengers in one quarter, regardless of the type of service. I assume that a firm will enter a market as long as it can realize non-negative profit from entry.

Column (I) shows the confidence intervals when I restrict $a_i = \alpha$ and $\delta^i_j = \delta_j \forall i, j$. For example, the effect of Southwest’s presence on the profits of other airlines is given by $\delta_{WN}$, while the effect of Delta’s presence on the profits of other airlines is given by $\delta_{DL}$. The estimates of $\delta$’s are reported as “competitive effects”. All the $\delta$’s are estimated to be negative, which is consistent with the hypothesis that profits decline when another firm enters the market. However, there is some heterogeneity in the effects that firms have on one another. The row titled AA shows the estimates for the effect of American on the profits of other airlines. I estimate the competitive effect of American to be [-23.298, -21.602]. The competitive effects of Delta, US Airways, United, and medium airlines (MA) are very similar to this result. Conversely, small low-cost carriers (LCC) have a much stronger competitive effect. The estimate of this effect is [-26.653, -24.935]. Southwest generates the strongest effect on other airlines, with an estimate of [-28.798, -25.071].

In column (I), the coefficient of airport presence is [0.112, 0.242]. This means that airport presence has a positive effect on the profit of a firm, i.e., as the number of markets that a firm serves at an airport increases, the profit that the firm can earn in the market increases as well. Cost has a negative effect on the profit function ([-0.473, -0.209]), as does slot control ([-4.269, -3.581]). The rest of the market-level variables have positive effects on profits, namely, per capita income ([5.435, 5.892]), income growth rate ([1.009, 1.884]), market size ([5.187, 5.899]), market distance ([1.082, 2.050]), and closest airport ([0.568, 1.663]).
Table 3: Profit Estimations: Aggregate Across Product Types

<table>
<thead>
<tr>
<th></th>
<th>(I)</th>
<th>(II)</th>
<th>(III)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Competitive effect</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>[-23.298, -21.602]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL</td>
<td>[-22.390, -21.245]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>[-22.181, -20.862]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UA</td>
<td>[-20.408, -18.833]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>[-20.386, -19.098]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCC</td>
<td>[-26.653, -24.935]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WN</td>
<td>[-28.798, -25.071]</td>
<td>[-27.999, -24.948]</td>
<td></td>
</tr>
<tr>
<td>WN on AA</td>
<td></td>
<td>[-20.778, -15.141]</td>
<td></td>
</tr>
<tr>
<td>WN on DL</td>
<td></td>
<td>[-30.939, -24.970]</td>
<td></td>
</tr>
<tr>
<td>WN on US</td>
<td></td>
<td>[-24.811, -19.903]</td>
<td></td>
</tr>
<tr>
<td>WN on UA</td>
<td></td>
<td>[-22.025, -15.706]</td>
<td></td>
</tr>
<tr>
<td>WN on MA</td>
<td></td>
<td>[-30.178, -21.111]</td>
<td></td>
</tr>
<tr>
<td>WN on LCC</td>
<td></td>
<td>[-31.460, -28.342]</td>
<td></td>
</tr>
<tr>
<td><strong>Airport presence</strong></td>
<td>[0.112, 0.242]</td>
<td>[0.099, 0.132]</td>
<td>[0.080, 0.447]</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>[-0.473, -0.209]</td>
<td>[-0.244, 0.003]</td>
<td>[-0.810, -0.417]</td>
</tr>
<tr>
<td><strong>Per capita income</strong></td>
<td>[5.435, 5.892]</td>
<td>[2.494, 2.906]</td>
<td>[1.088, 2.156]</td>
</tr>
<tr>
<td><strong>Income growth rate</strong></td>
<td>[1.009, 1.884]</td>
<td>[0.727, 0.832]</td>
<td>[0.513, 1.178]</td>
</tr>
<tr>
<td><strong>Slot control</strong></td>
<td>[-4.269, -3.581]</td>
<td>[-2.697, -2.370]</td>
<td>[-3.246, -1.136]</td>
</tr>
<tr>
<td><strong>Market size</strong></td>
<td>[5.187, 5.899]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-WN</td>
<td>[4.201, 4.368]</td>
<td>[1.196, 3.235]</td>
<td></td>
</tr>
<tr>
<td>WN</td>
<td>[8.807, 8.869]</td>
<td>[6.988, 9.986]</td>
<td></td>
</tr>
<tr>
<td><strong>Market distance</strong></td>
<td>[1.082, 2.050]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-WN</td>
<td>[0.775, 0.879]</td>
<td>[-0.265, 1.153]</td>
<td></td>
</tr>
<tr>
<td>WN</td>
<td>[-7.210, -4.749]</td>
<td>[-10.742, -9.497]</td>
<td></td>
</tr>
<tr>
<td><strong>Closest airport</strong></td>
<td>[0.568, 1.663]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-WN</td>
<td>[0.294, 0.454]</td>
<td>[-1.035, 2.435]</td>
<td></td>
</tr>
<tr>
<td>WN</td>
<td>[-3.912, -2.973]</td>
<td>[-2.427, -1.910]</td>
<td></td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>[-8.600, -6.148]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-WN</td>
<td>[-6.429, -6.280]</td>
<td>[-10.258, -6.542]</td>
<td></td>
</tr>
<tr>
<td>WN</td>
<td>[-7.571, -7.449]</td>
<td>[-6.888, -6.101]</td>
<td></td>
</tr>
</tbody>
</table>

Note: I report the cube that contains the set of parameters that cannot be rejected at the 95% confidence level. In this table, “WN” represents Southwest and “Non-WN” represents non-Southwest carriers.
Column (II) in Table 3 shows the confidence intervals when I relax the assumption $\alpha_i = \alpha \forall i$, but still assume that $\delta^j_i = \delta^j \forall i, j$. Moreover, I code the competitive effects of American, Delta, US Airways, United, the type MA, and the type LCC as the effect of a non-Southwest firm. Therefore, $\delta_{\text{Non-SW}}$ measures the competitive effect of a non-Southwest carrier, for example, American, while $\delta_{\text{SW}}$ measures the competitive effect of Southwest. In this setting, the effect of Southwest’s presence on the profits of other airlines, which is its competitive effect, is estimated to be [-27.999, -24.948]. This is larger than the competitive effect of non-Southwest airlines, whose estimate is [-22.171, -20.101].

In column (II), the coefficient estimates for market size, market distance, and closest airport are quite different for non-Southwest airlines, than those of Southwest. In particular, I estimate the effect of market size to be [4.201, 4.368] for non-Southwest airlines, while for Southwest the effect is [8.807, 8.869]. In terms of market distance and closest airport, these two variables have positive effects on the profits of non-Southwest airlines ([0.775, 0.879] and [0.294, 0.454]), but have negative effects on the profit of Southwest ([7.210, 4.749] and [-3.912, -2.973]).

Column (III) uses a similar setting as column (II), except it allows for Southwest’s effect on various airlines to be different. That is to say, I drop the assumption $\delta^i_{\text{WN}} = \delta_{\text{WN}} \forall i$. Therefore, $\delta^i_{\text{AA}}$ measures the competitive effect of Southwest on American’s profit, while $\delta^i_{\text{DL}}$ measures the competitive effect of Southwest on Delta’s profit. Nevertheless, the competitive effect of a non-Southwest carrier, for example, Delta, is still captured by $\delta_{\text{Non-SW}}$, regardless of the identity of the opponent. I find that Southwest has a negative competitive effect on all competitors, but the magnitude varies. The competitive effect of Southwest on type LCC is the largest ([-31.460, -28.342]), followed by the effect on type MA ([30.178, -21.111]) and Delta ([30.939, -24.970]). The effect of Southwest on American is the smallest ([20.778, -15.141]).

By comparing columns (II) and (III), I find that the coefficient estimates for some exogenous variables are very different (between the two columns). For example, in column (II) the effect of market distance for Southwest is [-7.210, 4.749], but in column (III) the effect is [-10.742, -9.497].
This suggests that the assumption of a homogeneous competitive effect, on various opponents, introduces some bias into the estimates of exogenous variables.

In short, these results show that Southwest’s presence has a very strong negative impact on the profits of other firms. This impact varies by the identity of the firms. While small low-cost carriers and medium airlines are seriously impacted, large carriers are generally less impacted, with the exception of Delta.

5.6 Empirical Results: Examine Different Product Types

I now break down entry by product types. Each firm can enter a market with either a connecting or a nonstop service, or both. The profit of a firm’s nonstop (connecting) service is determined by its own connecting (nonstop) presence, its competitors’ connecting presence and nonstop presence, as well as the exogenous variables.

Table 4 reports the estimates of competitive effects from estimating model (3) using Sample-B. In this instance, I assume that a firm will provide a nonstop (connecting) service as long as it can realize non-negative nonstop (connecting) profit from entry. The coefficients of interest are $\delta$’s. They summarize the competitive effect of entry by different firms and different types of service. For example, $\delta_{WN,connect}^{WN,nonstop}$ captures the effect of Southwest’s nonstop entry on its own connecting profit; $\delta_{Non-WN,connect}^{WN,nonstop}$ captures the effect of Southwest’s nonstop entry on the profit of the connecting service of a non-Southwest firm, for example, Delta; $\delta_{Non-WN,nonstop}^{Non-WN,connect,samefirm}$ captures the effect of a non-Southwest firm’s nonstop entry on its own connecting profit; and $\delta_{Non-WN,nonstop}^{Non-WN,connect,otherfirm}$ captures the effect of a non-Southwest firm’s nonstop entry on the profit of the connecting service of another non-Southwest firm (e.g., the effect of Delta’s nonstop entry on United’s connecting profit).
Table 4: Competitive Effects: Examine Different Product Types

<table>
<thead>
<tr>
<th></th>
<th>(I) WN connect</th>
<th>(II) WN nonstop</th>
<th>(III) Non-WN connect</th>
<th>(IV) Non-WN nonstop</th>
</tr>
</thead>
</table>

Note: I report the cube that contains the set of parameters that cannot be rejected at the 95% confidence level. In this table, “WN” represents Southwest and “Non-WN” represents non-Southwest carriers.

Column (I) in Table 4 shows the effect of Southwest’s connecting presence on its own nonstop profit, on a non-Southwest firm’s connecting profit, and on a non-Southwest firm’s nonstop profit. I find that Southwest’s connecting presence is positively associated with its own nonstop profit ([9.978, 10.623]), but it is negatively associated with other firms’ connecting and nonstop profits ([[-19.488, -17.793] and [-15.941, -14.055]). Moreover, the effect on competitors’ connecting profits is larger than that on their nonstop profits. This is because Southwest’s connecting product is competing head-to-head with competitors’ connecting products but only partially with their nonstop products. More importantly, a connecting service is considered low quality, so its presence should not affect the high-quality product, nonstop service, to a significant degree.
Column (II) summarizes the competitive effects of Southwest’s nonstop service. I find that Southwest’s nonstop presence is positively associated with its own connecting profit ([15.669, 17.054]). This effect is not symmetric. Nonstop presence boosts connecting presence more than connecting presence boosts nonstop presence. The reason because as long as Southwest has nonstop flights between two airports, it can offer connecting flights via a third airport where it already has presence at a very low cost. Conversely, when it has connecting flights between two airports, starting a nonstop service can still be costly. In addition, Southwest’s nonstop presence is negatively associated with opponents’ connecting and nonstop profits ([−25.895, −24.112] and [−23.174, −19.266]). The effect on connecting profits is larger than that on nonstop profits. Given that connecting service is low quality, and nonstop service is high quality, the result means that the entry of a high-quality product affects both high-quality and low-quality products, with a larger impact on low-quality products.

Columns (III) and (IV) summarizes the competitive effects of non-Southwest firms’ connecting service and nonstop service, respectively. Again, I find that for a single firm, its nonstop presence boosts connecting presence ([16.895, 18.182]) more than its connecting presence boosts nonstop presence ([7.438, 8.322]). Both connecting and nonstop presence have a negative impact on other firms’ profits. In terms of connecting presence, its impact on opponents’ connecting profits (between -16.913 and -12.180) is larger than that on nonstop profits (between -12.022 and -10.275). In terms of nonstop presence, its impact on opponents’ connecting profits (between -25.610 and -18.219) is also larger than that on nonstop profits (between -20.488 and -15.045).

Furthermore, by comparing columns (III) and (IV), the competitive effect of a connecting product is generally smaller that of a nonstop product. This result is still true if columns (I) and (II) are compared. In addition, by comparing columns (I) and (III), the competitive effect of Southwest’s products is generally larger than the competitive effect of non-Southwest firms’ products. This result is still true if columns (II) and (IV) are compared.

Overall, these results suggest that in a market with differentiated products, the entry of a low-quality product affects competitors’ profits less than the entry of a high-quality product does. When facing the same type of entry, the profit of a low-quality product is more seriously affected than
that of a high-quality product. The latter result is also consistent with my finding in Section 4, which reveals that upon Southwest’s entry, incumbent legacy carriers cut prices more for connecting flights than for nonstop flights.

6 Counterfactual

In this section, I perform counterfactual experiments to assess the extent to which the entry of Southwest influences the entry of other airlines and the equilibrium number of firms in the market. Essentially, I conduct the counterfactuals by setting the competitive effects of Southwest equal to zero and then recomputing the new equilibria.

6.1 How Does Southwest Influence the Entry Decision of Each Competitor?

The effect of Southwest’s presence on the entry decision of a particular firm can be captured by the change in the probability of observing that firm in a market before and after Southwest is counterfactually removed. In particular, if the change is positive, i.e., the probability of observing the firm increases with Southwest being removed, then the entry of this firm is discouraged by Southwest. The larger in the change of probability, the more Southwest affects the firm’s entry decision.

Before presenting the results, I clarify an important point. Normally, there are 32 market structures in which a given firm can be observed. For example, for Delta, it can be observed as a monopoly, as a duopoly with United, and so on. If there were no multiple equilibria, this would not present any difficulty; I could simply sum over the probability of all the market structures where Delta is in the market and that would yield the total probability of observing Delta in the market. However, there are multiple equilibria and I only observe the lower and upper bounds on the probabilities of each market structure. Summing over the upper bounds of the probabilities of all the market structures where Delta is observed is problematic because the maximum probability of observing
one market structure (e.g., a Delta monopoly), necessarily excludes seeing another market structure (e.g., a duopoly with Delta and United) with its maximum probability.

In Table 5, I report the largest positive and negative changes in the average upper bounds of the probabilities of observing a given carrier in any possible market structure. I report both the positive and negative changes because, in this instance, I am looking at the simultaneous decision of all firms. Although removing Southwest increases the profits of all firms (the competitive effect of Southwest is negative and thus all firms individually are more likely to enter), in a simultaneous entry setting I may still see that some market structures are more likely to be observed at the expense of other market structures. So one particular firm may end up with a dominant negative effect.

In practice, I compute the average upper bounds by taking the means of the upper bounds for one market structure across markets. I do this computation both before and after Southwest is counterfactually removed. Then, for a given carrier, I take the changes of average upper bounds for all 32 market structures where the carrier can be observed and report the largest positive and negative changes among them.

<table>
<thead>
<tr>
<th>Airline</th>
<th>Positive</th>
<th>Negative</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>0.545</td>
<td>-0.091</td>
<td>0.356</td>
<td>-</td>
</tr>
<tr>
<td>DL</td>
<td>0.583</td>
<td>-0.11</td>
<td>0.398</td>
<td>-</td>
</tr>
<tr>
<td>US</td>
<td>0.449</td>
<td>-</td>
<td>0.350</td>
<td>-</td>
</tr>
<tr>
<td>UA</td>
<td>0.553</td>
<td>-0.178</td>
<td>0.357</td>
<td>-</td>
</tr>
<tr>
<td>MA</td>
<td>0.588</td>
<td>-0.167</td>
<td>0.401</td>
<td>-</td>
</tr>
<tr>
<td>LCC</td>
<td>0.596</td>
<td>-0.116</td>
<td>0.404</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: I report the largest positive and negative changes in the average upper bounds of the probabilities of observing a given carrier in any possible market structure.
Column (I) in Table 5 shows the results for when I use the estimates of column (I) in Table 3 to recompute the new equilibria. The actual parameter values that are used are the middle points of the confidence intervals. For example, the airport presence coefficient estimate is [0.112, 0.242]; then I use 0.177 (= (0.112 + 0.242)/2) to recompute the equilibria. I find that for every firm, the change in the average upper bounds is more on the positive side, but the magnitude varies by the identity of the firm. For example, for American, the probability of observing it in the market may increase by as much as 54.5%, but it may also decrease by up to 9.1%. For US Airways, the probability of observing it always increases, with the largest possible increase being 44.9%.

Column (II) presents the results when I use the estimates of column (III) in Table 3 to recompute the new equilibria. All changes in the average upper bounds are computed to be non-negative, but as with the results of column (I), the magnitude varies by the identity of firms. In particular, the probability of observing small low-cost carriers increases the most, by as much as 40.4%, and the probability of observing US Airways increases the least, by as much as 35%.

These results imply that Southwest has a substantial impact on the entry decision of each competitor. Once Southwest is removed, each firm is more likely to enter the market.

6.2 How Does Southwest Influence the Number of Non-Southwest Firms?

The effect of Southwest’s presence on the number of non-Southwest firms in the market can be captured by the change in the probability of observing a given number of non-Southwest firms before and after Southwest is counterfactually removed. If eliminating Southwest decreases the probability of observing zero non-Southwest firms and increases the probability of observing one, two, and three non-Southwest firms, then the number of non-Southwest firms is negatively affected by Southwest. The larger in the change of probability, the more Southwest affects the equilibrium number of firms.
In Table 6, I report the maximum and minimum changes in the average upper bounds of the probabilities of observing a given number of non-Southwest firms in any possible market structure. The average upper bounds are computed by taking the means of the upper bounds for one market structure across markets. For a given number of non-Southwest firms, I take the differences of the average upper bounds before and after Southwest is counterfactually removed for all market structures in which this many non-Southwest firms are observed. I then report the maximum and minimum changes among them.

However, there is one important exception. There is only one market structure where zero non-Southwest firms are observed. In this case, the change in the average upper bounds is a unique number.

Table 6: Changes in the Average Upper Bounds when Southwest is Counterfactually Removed

| Number of non-Southwest airlines | (I) use the estimates of column (I) in Table 3 | (II) use the estimates of column (III) in Table 3 |
|---------------------------------|-------------------------------------------|--|-------------------------------------------|--|
|                                 | Maximum   | Minimum   | Maximum   | Minimum   |
| 0                               | -0.510    | -0.510    | -0.597    | -0.597    |
| 1                               | 0.335     | 0.222     | 0.361     | 0.350     |
| 2                               | 0.583     | 0.471     | 0.254     | 0.246     |
| 3                               | 0.226     | 0.103     | 0.114     | 0.077     |

Note: I report the maximum and minimum changes in the average upper bounds of the probabilities of observing a given number of non-Southwest carriers in any possible market structure.

Column (I) in Table 6 shows the results when I use the estimates of column (I) in Table 3 to recompute the new equilibria. Again, the actual parameter values that are used are the middle points of the confidence intervals. I find that removing Southwest decreases the probability of observing zero non-Southwest airlines by as much as 51%. At the same time, the probability of observing one, two, and three non-Southwest airlines increases by as much as 33.5%, 58.3%, and 22.6%, respectively. This implies that Southwest has a strong negative impact on the number of
non-Southwest firms. Once it is excluded, we are likely to observe more non-Southwest firms in the market.

Column (II) presents the results when I use the estimates of column (III) in Table 3 to recompute equilibria. Similarly, I find that eliminating Southwest decreases the probability of observing zero non-Southwest airlines by as much as 59.7%, and at the same time increases the probability of observing one, two, and three non-Southwest airlines by as much as 36.1%, 25.4%, and 11.4%, respectively.

Next, I use Berry (1992)’s method to evaluate the change in the mean number of firms. This method contends that, under certain assumptions, we can get a unique prediction of the number of firms that enter a market, although we may not be able to predict the identities of the firms that enter. The assumptions include homogeneity in firms’ competitive effects and heterogeneity only in firms’ fixed costs. Notice that my setting of non-Southwest firms in column (II) of Table 3 satisfies these assumptions. Hence, I can use those estimates to predict the equilibrium number of non-Southwest firms, where Southwest is counterfactually removed from each market.

Table 7 shows the result. The actual mean number of non-Southwest airlines is 1.883 when Southwest is still in place. The predicted mean number of non-Southwest airlines is 2.544 when Southwest is counterfactually eliminated from each market. This implies that Southwest has a negative impact on the number of non-Southwest firms. Once it is removed, the equilibrium number increases significantly.

| Table 7: Mean Number of Non-Southwest Firms |
|------------------------------------------|---------------------------------|
| Prediction from the model                | Actual data                     |
| (with Southwest being counterfactually removed) | (with Southwest still in place) |
| Mean Number                              | 2.544                           | 1.883                           |
7 Conclusion

This paper studies the effect of Southwest Airlines on various aspects of the airline industry, including pricing, profits, entry decisions, and the number of firms. I incorporate both nonstop and connecting service in the analysis. I find that legacy carriers cut both connecting and nonstop prices in response to Southwest’s entry. Moreover, these price cuts are more significant for connecting service than for nonstop service. By estimating a static game of simultaneous entry, I find that Southwest has a very strong negative impact on the profits of its competitors. This impact is firm-specific. The profits of medium airlines and small low-cost carriers are more seriously impacted than those of larger airlines. After examining entry by product types, I find that the entry of a low-quality product affects opponents’ profits less than the entry of a high-quality product does. If facing the same type of entry, the profit of a low-quality product is more seriously influenced by the entrant than that of a high-quality product. In this instance, a low-quality product is a connecting service and a high-quality product is a nonstop service. Finally, through counterfactual experiments, I find that Southwest has a remarkable impact on the entry decision of each competitor and on the equilibrium number of non-Southwest firms in the market.

This paper expands the empirical literature in several key ways. To the best of my knowledge, it is the first to confirm that Southwest’s entry leads to a decrease in incumbents’ connecting fares using price variation within a route. It is also the first to evaluate the effect of Southwest’s presence on each competing carrier’s profit based on a partial identification approach. Moreover, it adds to the literature on multiproduct entry by examining nonstop and connecting service. Last but not least, the counterfactual experiments carried out in this paper are unique.

There are two important limitations to these findings. First, I impose strong assumptions on the joint distribution of the unobservables. It would be ideal if these assumptions could be relaxed and I could still study the identification problem in the model. Second, I assume that each firm takes its entire network and the networks of its competitors as givens. It would be interesting if one could construct a more complicated model that accounts for the dynamics of networks.
References


https://www.sec.gov/Archives/edgar/data/4515/000119312516474605/d78287d10k.htm,
https://www.sec.gov/Archives/edgar/data/27904/000002790415000003/dal1231201410k.htm,
https://www.sec.gov/Archives/edgar/data/92380/000009238015000027/luv-12312014x10k.htm,

## Appendix A  Additional Tables

### Table 8: Operating Costs for Carriers of Interest

<table>
<thead>
<tr>
<th>Airline</th>
<th>Operating costs per ASM (cents)</th>
<th>Salaries and related costs per ASM (cents)</th>
<th>Maintenance materials and outside repairs per ASM (cents)</th>
<th>Aircraft fuel and related taxes per ASM (cents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>13.42</td>
<td>3.58</td>
<td>0.86</td>
<td>4.46</td>
</tr>
<tr>
<td>Delta</td>
<td>15.92</td>
<td>3.39</td>
<td>0.76</td>
<td>4.87</td>
</tr>
<tr>
<td>United</td>
<td>14.03</td>
<td>4.17</td>
<td>0.83</td>
<td>5.45</td>
</tr>
<tr>
<td>Southwest</td>
<td>12.50</td>
<td>4.14</td>
<td>0.75</td>
<td>4.04</td>
</tr>
</tbody>
</table>

Note: All costs are for the twelve month period ended December 31, 2014.
Source: Form 10-K, for fiscal year ended December 31, 2014 for each respective carrier.

### Table 9: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>N of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average ticket prices for incumbents’ connecting flights</td>
<td>192.85</td>
<td>60.9</td>
<td>48,662</td>
</tr>
<tr>
<td>Average ticket prices for incumbents’ nonstop flights</td>
<td>196.53</td>
<td>66.2</td>
<td>22,315</td>
</tr>
</tbody>
</table>

Notes: Author’s calculations using the DB1B database from the U.S. Department of Transportation.
Table 10: Legacy Carriers Respond to Entry: Mean Fare

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>(I) ( \text{lnp_nonstop} )</th>
<th>(II) ( \text{lnp_connecting} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 quarters before entry ( (t_0 - 8) )</td>
<td>-0.022* (0.013)</td>
<td>0.006 (0.006)</td>
</tr>
<tr>
<td>7 quarters before entry ( (t_0 - 7) )</td>
<td>-0.03* (0.013)</td>
<td>-0.016* (0.006)</td>
</tr>
<tr>
<td>6 quarters before entry ( (t_0 - 6) )</td>
<td>-0.031* (0.014)</td>
<td>-0.002 (0.006)</td>
</tr>
<tr>
<td>5 quarters before entry ( (t_0 - 5) )</td>
<td>-0.019 (0.014)</td>
<td>-0.005 (0.006)</td>
</tr>
<tr>
<td>4 quarters before entry ( (t_0 - 4) )</td>
<td>-0.025* (0.014)</td>
<td>0.014* (0.007)</td>
</tr>
<tr>
<td>3 quarters before entry ( (t_0 - 3) )</td>
<td>-0.029* (0.015)</td>
<td>0.008 (0.007)</td>
</tr>
<tr>
<td>2 quarters before entry ( (t_0 - 2) )</td>
<td>-0.038* (0.016)</td>
<td>-0.002 (0.007)</td>
</tr>
<tr>
<td>1 quarter before entry ( (t_0 - 1) )</td>
<td>-0.04** (0.016)</td>
<td>-0.019* (0.007)</td>
</tr>
<tr>
<td>entry ( (t_0) )</td>
<td>-0.064*** (0.016)</td>
<td>-0.062*** (0.008)</td>
</tr>
<tr>
<td>1 quarter after entry ( (t_0 + 1) )</td>
<td>-0.071*** (0.016)</td>
<td>-0.083*** (0.008)</td>
</tr>
<tr>
<td>2 quarters after entry ( (t_0 + 2) )</td>
<td>-0.076*** (0.016)</td>
<td>-0.079*** (0.008)</td>
</tr>
<tr>
<td>3 quarters after entry ( (t_0 + 3) )</td>
<td>-0.056*** (0.018)</td>
<td>-0.069*** (0.009)</td>
</tr>
<tr>
<td>4 quarters after entry ( (t_0 + 4) )</td>
<td>-0.061*** (0.018)</td>
<td>-0.078*** (0.009)</td>
</tr>
<tr>
<td>5 quarters after entry ( (t_0 + 5) )</td>
<td>-0.049** (0.019)</td>
<td>-0.084*** (0.01)</td>
</tr>
<tr>
<td>6 quarters after entry ( (t_0 + 6) )</td>
<td>-0.057** (0.02)</td>
<td>-0.082*** (0.01)</td>
</tr>
<tr>
<td>7 quarters after entry ( (t_0 + 7) )</td>
<td>-0.049* (0.021)</td>
<td>-0.065*** (0.012)</td>
</tr>
<tr>
<td>8 quarters after entry ( (t_0 + 8) )</td>
<td>-0.056** (0.021)</td>
<td>-0.087*** (0.012)</td>
</tr>
<tr>
<td>9 to infinite quarters after entry ( (t_0 + 9) )</td>
<td>-0.052*** (0.016)</td>
<td>-0.073*** (0.005)</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>-0.003 (0.006)</td>
<td></td>
</tr>
<tr>
<td>( N ) of observations</td>
<td>22,315</td>
<td>48,662</td>
</tr>
</tbody>
</table>

Notes: The dependent variables are average logged fares. Column (I) shows estimates for incumbents’ nonstop fares. Column (II) shows estimates for incumbents’ connecting fares. *Denotes significance at 10% level. **Denotes significance at 5% level. ***Denotes significance at 1% level.
Appendix B  Hubs and Focus Airports

In this study, I consider the following hubs and focus airports:

For American, hubs are Boston Logan, Dallas/Fort Worth, New York Kennedy, Los Angeles, Miami, and Chicago O’Hare.

For Delta, hubs are Hartsfield-Jackson Atlanta, Cincinnati/Northern Kentucky, Detroit, New York Kennedy, Memphis, Minneapolis-Saint Paul, and Salt Lake City.


For United, hubs are Washington Dulles, Los Angeles, and Chicago O’Hare.

For Continental, hubs are Newark Liberty and Houston George Bush.

For Alaska Airlines, hubs are Ted Stevens Anchorage, Los Angeles, Portland, and Seattle-Tacoma.

For Southwest, focus airports are Baltimore/Washington, Dallas Love Field, Houston William P. Hobby, Las Vegas McCarran, Los Angeles, Chicago Midway, and Oakland.

For Allegiant Air, focus airports are Las Vegas McCarran, Los Angeles, and Orlando.

For Frontier, focus airports are Denver and Cleveland Hopkins.

For Spirit, focus airports are Detroit and Fort Lauderdale-Hollywood.

For JetBlue, focus airports are Boston Logan, Fort Lauderdale-Hollywood, New York Kennedy, and Orlando.

For Virgin, focus airports are Los Angeles and San Francisco.

For Sun Country Airlines, focus airport is Minneapolis-Saint Paul.

For AirTran Airways, focus airports are Hartsfield-Jackson Atlanta, Baltimore/Washington, Orlando, and Milwaukee General Mitchell.
Appendix C  Simulation and Related Issues

C.1 Objective Function

Assume that $X = (S, Z)$ represent the exogenous variables, and $\theta = (\alpha, \beta, \delta)$ represent the parameters to be estimated.

If there are $K$ potential entrants, then there are $2^K$ possible equilibrium outcomes. A particular equilibrium outcome $y = (y_1, y_2, ..., y_K)$ is a sequence of zeroes and ones, e.g., American and Southwest are on the market, but no one else.

Note that each element in $y$ is endogenous. A potential entrant will actually enter a market as long as it can realize nonnegative profits from entry, i.e., $y_i = 1[pi_i(X, \theta, y_{-i}, u_i) \geq 0], \forall i \in \{1, ..., K\}$.

Assume $Pr(y|X)$ is the probability function for outcome $y$ given exogenous variables $X$. The goal is to partially identify the parameters of interest without specifying this function.

To obtain the identified set, noticing that the probability function is bounded between 0 and 1, we can further get

$$
\int_{R_1(X, \theta)} dF(u) \leq Pr(y|X) \leq \int_{R_1(X, \theta)} dF(u) + \int_{R_2(X, \theta)} dF(u)
$$

where $R_1$ is the region in which $y$ is the unique observable outcome of the entry game, and $R_2$ is the region in which the game admits multiple potentially observable outcomes, one of which is $y$. 


These bounds can then be written in vectorized format for every possible $X$ and a value of the parameters, $\theta$, as

$$
\begin{bmatrix}
H_1^1(X, \theta) \\
\vdots \\
H_1^k(X, \theta) \\
\end{bmatrix} \leq 
\begin{bmatrix}
\Pr(y_1|X) \\
\vdots \\
\Pr(y_k|X) \\
\end{bmatrix} \leq 
\begin{bmatrix}
H_2^1(X, \theta) \\
\vdots \\
H_2^k(X, \theta) \\
\end{bmatrix}
$$

or in vector format

$$
H_1(X, \theta) \leq \Pr(y|X) \leq H_2(X, \theta)
$$

The model is estimated by ensuring that the observed probabilities of each equilibrium outcome for every $X$, lies between the upper and lower bounds predicted by the model. The way to do this is by searching for the $\theta$ that minimizes

$$
Q(\theta) = \int [|| \Pr(y|X) - H_1(X, \theta)|| - || \Pr(y|X) - H_2(X, \theta)||] dF_x(X)
$$

which simply penalizes lower (upper) bounds predicted by the model that exceed (are less than) the observed probability of each equilibrium outcome.

In practice, $N$ points are drawn out of the distribution of $dF_x(X)$ and the sample objective function is computed as

$$
Q_N(\theta) = \sum_{n=1}^{N} [|| \Pr(y|X) - H_1(X, \theta)|| + || \Pr(y|X) - H_2(X, \theta)||]
$$

where $\Pr(y|X)$ is a consistent estimate of the true probability of each equilibrium outcome (it is computed in the first stage of the estimation procedure), and $H_1(X, \theta)$ and $H_2(X, \theta)$ are simulated estimates of the lower and upper bounds predicted by the model for each of the equilibrium outcomes for a particular $X$.

### C.2 First Stage Estimation

The objective function involves calculating $\Pr(y|X)$, a consistent estimate of the true probability of each equilibrium outcome in the first stage. To do this, I first discretize the variables and then use a nonparametric frequency estimator. There are many ways to discretize. In this paper, I run
all results with a coarse grid that discretizes all continuous variables into four separate bins, according to the 0, 25, 50, and 75th quantiles.\(^{15}\)

The nonparametric frequency estimator consists of counting the fraction of markets with a given realization of the exogenous variables where a given market structure is observed. In particular, I use a simple frequency estimator to get the conditional choice probabilities:

\[
Pr(y|X) = \frac{\sum_{n=1}^{N} 1[y_n = y] 1[X_n = X]}{\sum_{n=1}^{N} 1[X_n = X]}
\]

where the exogenous variables have finitely many support points (discrete support) such that

\[X \in S_x = \{X_1, \ldots, X_N\}\]

C.3 Error Term

The error term in model (2), \(u_{im}\), consists of four parts: (i) a firm-specific unobserved heterogeneity, \(u_i\); (ii) a market-specific unobserved heterogeneity, \(u_m\); (iii) two airport-specific unobserved heterogeneity, \(u_o\) and \(u_d\), where \(u_o\) is an error that is common across all markets whose origin is \(o\) and \(u_d\) is an error that is common across all markets whose origin is \(d\).\(^{16}\) \(u_{im}\) is the sum of all four errors.

The error term in model (3), \(u_{im}^p\), is obtained by adding an additional error term, \(u_\varphi\), to \(u_{im}\), where \(u_\varphi\) is an error that is that is common across all products whose type is \(\varphi\).

I assume that \(u_i, u_m, u_o, u_d, \text{ and } u_\varphi\) are all independent and normally distributed. Moreover, I assume that the unobservables are not correlated with the exogenous variables. Notice that this assumption would be clearly violated if I were to use variables that the firm can choose, such as

---

\(^{15}\)This discretization is necessary since inference procedures with a nonparametric first step with continuous regressors have not been developed.

\(^{16}\)Recall that the markets are defined irrespective of the direction of the flight. Thus, the use of the terms “origin” and “destination” means either one of the market endpoints.
prices or quantities. However, I am considering a reduced form profit function, where all of the control variables (e.g., population, income, and distance) are maintained to be exogenous.

Finally, recall that this is a game of complete information, hence \( u_{lm} \) and \( u^o_{lm} \) are observed by all players in market \( m \).

### C.4 Step-by-step Simulation Procedure

The simulation procedure requires to calculate a lower and upper bound, \( H_1(X, \theta) \) and \( H_2(X, \theta) \), for every \( X \) and a guess of the parameter values \( \theta \). Let’s take the estimation of model (2) as an example. The procedure is as follows:

1. Set \( H_1(X, \theta) = H_2(X, \theta) = 0 \).

2. For every market, every firm, every origin and destination airport, generate \( R \) draws respectively from the normal distribution with identity variance-covariance matrix. Here I set \( R = 100 \). For each simulation \( r = (1, \ldots, R) \), follow Steps 1-3:

**Step 1**: Transform the error term draws into a draw, and store it in \( u^r \).

**Step 2**: For a particular \( X \), a particular draw of the error term \( u^r \), and an initial guess of the parameter vector, \( \theta \), calculate the vector of firms’ profits for a particular set of entry decisions, \( y^g \) (for some \( g = 1, \ldots, 2^k \)):

\[
\pi(y^g, X, u^r, \theta)
\]

**Step 3**: If each firm is earning nonnegative profit, then the outcome \( y^g \) is an equilibrium (firms that don’t enter earn zero profits, firms that enter earn nonnegative profits):

\[
\pi(y^g, X, u^r, \theta) \geq 0
\]

**Step 4**: If this equilibrium is unique (for no other \( y^g \) is it true that \( \pi(y^g, X, u^r, \theta) \geq 0 \)), then add \( \frac{1}{R} \) to the lower and upper bound for this outcome. If the equilibrium is not unique, add \( \frac{1}{R} \) to only the upper bound for this outcome.
Step 5: Steps 2 through 5 are then repeated for every $X$ ($n = 1, \ldots, N$), $u^r$ ($r = 1, \ldots, R$), and each equilibrium outcome, $y^g$ ($g = 1, \ldots, 2^k$).

Step 6: Calculate the objective function, $Q_N(\theta)$, using the first stage estimates $\Pr(y|X)$ and the simulated estimates of $H_1(X, \theta)$ and $H_2(X, \theta)$.

Step 7: Repeat Steps 1 through 6 as searching for a value of $\theta$ that minimizes $Q_N(\theta)$.

The estimation of model (3) takes almost the same procedure. The only difference is that I draw additional errors for each product type.

C.5 Identification

The system of equation that is considered is similar to a simultaneous equation system except that the dependent variable takes finitely many values. CT (2009) shows that just like in the classical simultaneous equation system, exclusion restrictions help to identify the parameters. Here, exclusion restrictions consist of the variables that enter firm $i$’s profit function but not firm $j$’s.

In this paper, I assume that both the airport presence variable and the cost variable are exclusion restrictions. This means that the airport presence and cost of one carrier is excluded from the profit functions of its competitors. For example, the airport presence and cost of American is excluded from the profit function of Delta. Then these two variables are firm-specific variables that shift an individual firm’s profit function without changing its competitors’ profit functions. They help to identify the parameters.