Merger Analysis with Endogenous Prices and Product Characteristics
Generalized Theorem and Application to the U.S. Airline Industry

Ziyi Qiu

July 28, 2018

University of Chicago [1]

University of Illinois Urbana Champaign [2]

Abstract

This paper studies firms' endogenous choices of prices and product characteristics pre- and post-merger. The paper finds that firms' adjustments of post-merger prices and product characteristics depend on pre-merger market shares, net benefits of improving product characteristics (Definition 2.1), overall production efficiencies (Definition 2.2) and threshold market shares that balance marginal cost and markup

[1]Department of Economics, the University of Chicago. 1126 E. 59th Street, Chicago, IL 60637. Email: ziyiqiu@uchicago.edu.

[2]Department of Economics, University of Illinois Urbana Champaign. 214 David Kinley Hall, 1407 W. Gregory, Urbana, IL, 61801. Email: ziyiqiu@illinois.edu.

effects (Definition 2.3). A generalized theorem (Theorem 3.1) is provided to characterize the conditions to predict post-merger outcomes. An application of the 2010 merger of United and Continental Airlines demonstrates that the theorem achieves high prediction accuracy in predicting post-merger outcomes.

Keyword. Antitrust Analysis, Mergers and Acquisitions, Endogenous Product Characteristics, Airline Mergers.

1. INTRODUCTION AND LITERATURE REVIEW

Understanding how firms make production decisions is of fundamental importance in economics. The classic approach considers firms' optimal choices of prices to maximize profits[1, 3, 4, 25, 30]. While the literature considers endogenous prices, product characteristics are usually held exogenous. The assumption of exogenous product characteristics does bring concerns. Firstly, since product characteristics affect consumers' purchasing decisions and also the costs of production, it is reasonable that firms could gain a higher profit by adjusting product characteristics. Allowing both prices and product characteristics to be endogenous could potentially improve firms' profits and necessitate the reconsideration of the classical pricing theory with exogenous product characteristics. Secondly, endogenous product characteristics are generally supported by real data. Firms' adjustments over their product characteristics are widely observed in real applications [22, 29, 9, 15, 32, 33, 14, 11, 8]. Both concerns suggest that we should consider endogeneity of both prices and product characteristics as we study firms' competition behavior. Therefore, a re-evaluation of firms' pricing and product repositioning incentives is an important and timely research topic.

Realizing the importance and necessity of endogenous product characteristics, the current guidelines for merger analysis shall be reconsidered for improvement. The current benchmark merger guidelines issued by the U.S. Department of Justice and the Federal Trade Commission mainly focus on firms' adjustments of prices post-merger. Product characteristics are usually assumed to be exogenous and remain constant pre- and post-merger [6, 7, 13, 18, 26].

However, constant and exogenous product characteristics are unduly demanding assumptions and are generally not supported by real data, as we observe in many merger cases that firms change their product characteristics post-merger [2, 12, 24, 20, 23, 27]. While it becomes a more realistic concern when conducting merger analysis, the frontier literature has started to consider changes in firms' product characteristics in the process of merger evaluation. A series of recent papers [5, 10, 17, 19, 21, 23, 28, 31] has considered firms' optimal product characteristics in a variety of merger applications. Among them, Mazzeo (2003) [23] studied the U.S. airline industry and found that carriers' on-time performance is likely to deteriorate when markets become less competitive. His later paper (2012) [24] found that this observation could have substantial effects by allowing for repositioning, particularly in cases where the merging parties offered relatively similar products prior to the merger. Peters (2006) [27] showed that a merged airline tends to reduce flight frequency on segments where the merging carriers were competing with each other. Watson(2008) [33] focused on product variety decision in terms of the number of product offerings sold by eyewear retailers. It is found therein that per-firm product variety has a nonmonotonic relationship with competition. This finding again suggests that the optimal response following a merger could be either to increase or to decrease product variety. Gramlich (2009) [17] developed and estimated a model of the U.S. automobile industry in which firms choose the fuel efficiency of their new vehicles. In their model, firms provide more or less fuel efficiency depending on the stochastically changing gas price. Lee (2013) [20] studied the merger of Delta and Northwest Airlines and found that: 1) the merged firm

tends to increase product differentiation post-merger, and 2) the higher product differentiation reduces the firm's incentive to raise prices. He also argued that endogenizing product characteristics is essential to better predict the actual outcomes as the simulated results become closer to actual post-merger data. The results from these papers indicate that firms make distinct changes to their product characteristics, in addition to changes in prices post-merger.

However, there are some limitations of the existing works. Since the existing works are all case-by-case studies, there is a lack of generalized framework to serve as a merger guideline. Moreover, the often inconsistent conclusions among researchers make the generalized theorem a challenge to derive. For example, a series of papers including Berry and Waldfoger (2001) [5], Gandhi et al (2008) [14] and Sweeting (2010) [31] showed that merged firms tend to increase product differentiation to avoid market cannibalization. On the other hand, Gotz and Gugler (2006) [16] found that higher concentration in the retail gasoline market reduces product variety. Secondly, the current literature imposes strong assumptions of firms' homogenous production technology in order to recover costs of production. The assumption rules out the possibility that firms can be endowed with different production technologies, which is actually one of the key reasons that firms have different incentives to merge and induce different post-merger outcomes.

This paper uses disaggregate level data and studies firms' product repositioning and pricing incentives post-merger. The paper studies how the inclusion of endogenous product characteristics could affect firms' post-merger prices, product characteristics and market shares. Motivated by the limitations of

the current merger guidelines and the existing literature, this paper has two major contributions: 1) allowing firms to be differentiated in their production technologies and studying how heterogeneous productivities shall affect post-merger outcomes; 2) generalizing conditions to predict different post-merger outcomes under different market conditions, including changes in post-merger market shares, prices and product characteristics for both merged and non-merging firms. The paper finds that firms' adjustments of post-merger market shares, prices, and product characteristics are determined by pre-merger levels of market shares, net benefits of improving each product characteristic by one unit (Definition 2.1), overall production efficiencies (Definition 2.2) and threshold market shares that balance marginal cost and markup effects (Definition 2.3). The generalized theorem (our main Theorem 3.1) is then presented to predict post-merger outcomes for both merged and non-merging firms under different market conditions. The generalized theorem is then applied to study the 2010 merger of United and Continental Airlines. The empirical application suggests that the main theorem of the paper achieves high prediction accuracy in predicting post-merger outcomes in market shares, flight frequencies, and airfares for both the merged and non-merging firms.

The rest of the paper is organized as follows. Section 2 proposes the model with endogenous prices and product characteristics and generalizes conditions to predict post-merger market outcomes. Section 3 characterizes the generalized theorem for post-merger predictions of market shares, prices and product characteristics for both merged and non-merging firms. Section 4 describes the data and the basic features of the U.S. airline industry. Section 5 discusses

the identification strategy for estimating the demand and supply sides of the U.S. airline industry. Section 6 presents the estimation results and the merger prediction based on the estimated values of model parameters. Comparisons between the predicted post-merger changes of market shares, prices and product characteristics with the actual observed post-merger changes of the market outcomes are also shown in Section 6. The paper concludes in Section 7.

2. MODEL

In this section, we shall propose a model to study endogenous changes of firms' market shares, product characteristics and prices for both merged and non-merging firms post-merger. We shall consider a market with J firms, and each firm produces a product which can allow changes in K dimensions of product characteristics. The proposed model is based on the discrete choice framework as each consumer purchases the product with the highest utility. We consider the market with J major firms existing pre-merger. Without loss of generality, we assume firm 1 and firm 2 decide to merge. After the merger, firm 2 renames to firm 1 and adopts the same brand reputation and technology from firm 1. The new merged firm only produces the product of firm 1. There are (J-1) firms existing in the market post-merger, with firm 1 as the merged firm and firm 3 to firm J as the non-merging firms. Our model is general as the number of firms J and the number of product characteristics K can be any arbitrary number. We shall first propose the model by characterizing the demand and supply sides of the market pre- and post-merger. We then propose three definitions which are the key factors to determine post-merger market outcomes. In the end, we shall propose the main theorem.

2.1. *Demand Side Pre-merger*

We first characterize the demand side of the market in the pre-merger period. Let i, j and t be the consumer, firm and time index, respectively. The utility of consumer i choosing product j at time t is characterized as

$$(1) \qquad U_{ijt} = \sum_{k=1}^{K} \beta_k Z_{jkt} - \alpha P_{jt} + \xi_j + \xi_{jt} + \varepsilon_{ijt},$$

for $j = \{1, ..., J\}$. P_{jt} is the price for product j. $Z_{jt} = [Z_{j1t}, ..., Z_{jKt}]$ are the K major product characteristics that affect the consumer's utility. ξ_j is the brand fixed effect of firm j. ξ_{jt} contains the unobserved product characteristics term that also affects the consumer's utility. ε_{ijt} is the idiosyncratic shock term and follows type 1 extreme value distribution. To simplify the model, we assume that the individual's variation in the utility comes from the idiosyncratic shock term and we here do not consider the interaction of individual demographics with product attributes. By the property of type 1 extreme value (T1EV) distribution, the market share of firm j at time t is characterized as

$$(2) \qquad S_{jt} = \frac{\exp(\sum_{k=1}^{K} \beta_k Z_{jkt} - \alpha P_{jt} + \xi_j + \xi_{jt})}{1 + \sum_{j'=1}^{J} \exp(\sum_{k=1}^{K} \beta_k Z_{j'kt} - \alpha P_{j't} + \xi_{j'} + \xi_{j't})},$$

for $j = \{1, ..., J\}$. We assume that the consumer could also choose not to purchase any of the J products and instead purchase from the outside option. In this case, the consumer's utility of purchasing the outside option is

$$(3) \qquad U_{i0t} = \epsilon_{i0t},$$

and the market share of the outside option is

$$S_{0t} = \frac{1}{1 + \sum_{j'=1}^{J} \exp(\sum_{k=1}^{K} \beta_k Z_{j'kt} - \alpha P_{j't} + \xi_{j'} + \xi_{j't})}. \tag{4}$$

2.2. *Supply Side Pre-merger*

In this section, we shall describe each firm's profit maximization decision before the merger. Since we allow both price and product characteristics to be endogenous, each firm shall choose its optimal price and product characteristics simultaneously to maximize its profit. The profit of firm j is

$$\pi_{jt} = NS_{jt}(P_{jt} - mc_{jt}) - Fixed_{jt}, \tag{5}$$

where N is the total mass of consumers, S_{jt} is the market share for firm j characterized in equation (2) above, P_{jt} is the price that firm j charges to its consumers, mc_{jt} is firm j's marginal cost of production, and $Fixed_{jt}$ is firm j's fixed cost of production. It is sensible to assume that a firm's choices of product characteristics Z_{jt} shall affect both its marginal cost and fixed cost of production, as a high product quality should always require a higher amount of marginal and fixed costs to produce. In line with the large portion of the existing literature [20, 12], we take the assumptions of a linear marginal cost and a quadratic fixed cost of each firm as a function of its product characteristics.

Thus, the marginal cost and marginal fixed cost of each firm are characterized

as

$$mc_{jt} = \sum_{k=1}^{K} \gamma_{jk} Z_{jkt} + \omega_{jt}, \tag{6}$$

and

$$\frac{dFixed_{jt}}{dZ_{jkt}} = \delta_{jk} Z_{jkt} + \theta_{jt}, \tag{7}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$. ω_{jt} and θ_{jt} are the marginal and fixed cost unobserved terms. To use consistent notations throughout this paper, we shall denote the derivative of firm j's fixed cost with respect to its k-th product characteristic, i.e. $\frac{dFixed_{jt}}{dZ_{jkt}}$ the marginal fixed cost term.

2.3. *Necessary Conditions Pre-merger*

In this section, we shall derive the pre-merger necessary conditions with respect to product characteristics and price for each firm. By solving the necessary conditions, we can characterize each firm's equilibrium product price and characteristics as a function of its equilibrium market share. For each firm $j \in \{1, ..., J\}$, the necessary conditions for the optimal price P_{jt} and product characteristics Z_{jt} are characterized as (Appendix Note 1)

$$[P_{jt}]: \quad N(P_{jt} - mc_{jt})\frac{dS_{jt}}{dP_{jt}} + NS_{jt} = 0, \tag{8}$$

$$[Z_{jkt}]: \quad N(P_{jt} - mc_{jt})\frac{dS_{jt}}{dZ_{jkt}} - N\frac{dmc_{jt}}{dZ_{jkt}}S_{jt} - \frac{dFixed_{jt}}{dZ_{jkt}} = 0, \tag{9}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$, where $\frac{dmc_{jt}}{dZ_{jkt}} = \gamma_{jk}$ and $\frac{dFixed_{jt}}{dZ_{jkt}} = \delta_{jk} Z_{jkt} + \theta_{jt}$. Given that each firm chooses the optimal product characteristics and price to maximize its profit, we shall further simplify the necessary conditions for each firm pre-merger as (Appendix Note 2)

$$[P_{jt}] : P_{jt} - mc_{jt} = \frac{1}{\alpha(1 - S_{jt})}, \tag{10}$$

$$[Z_{jkt}] : NS_{jt}(\frac{\beta_k}{\alpha} - \gamma_{jk}) = \delta_{jk} Z_{jkt} + \theta_{jt}, \tag{11}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$. Rewriting equations (10) and (11) enables us to write the equilibrium product characteristics Z_{jkt} and price P_{jt} as a function of the firm's equilibrium market share S_{jt}

$$[P_{jt}] : P_{jt} = \sum_{k=1}^{K} [\gamma_{jk} NS_{jt} \left(\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}} \right) - \frac{\theta_{jt}\gamma_{jk}}{\delta_{jk}}] + \omega_{jt} + \frac{1}{\alpha(1 - S_{jt})}, \tag{12}$$

$$[Z_{jkt}] : Z_{jkt} = NS_{jt} \left(\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}} \right) - \frac{\theta_{jt}}{\delta_{jk}}, \tag{13}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$. Based on equations (12) and (13), solving the equilibrium market share guarantees the solutions of equilibrium product characteristics and price for each firm. These, together with the post-merger necessary conditions for each firm, enable us to characterize the changes of firms' post-merger prices and product characteristics based on the changes of firms' post-merger market shares, which we shall discuss in the later section.

2.4. *Prediction of Post-merger Market Shares*

In this section, we shall reconsider the demand and supply sides of the market in the post-merger period, and we shall study how the merger of two firms shall affect the post-merger market outcomes, in particular of firms' equilibrium market shares, product characteristics and prices. We now consider the merger of firm 1 and firm 2. The merged firm decides to keep only one product in the market, while the other one is forced to exit the market. Without loss of generality, we assume that the merged firm shall keep the product of firm 1, while the product of firm 2 exits the market post-merger. After the merger, there are (J-1) firms existing in the market, with firm 1 as the merged firm and firm 3 to firm J as the non-merging firms.

In the post-merger period, both the merged and non-merging firms shall choose the optimal post-merger prices and product characteristics to maximize profits. For firm 1 and firm 3 to firm J, the necessary conditions shall be the same as what we derive in equations (8) and (9) above, with the market shares consisting of (J-1) firms instead of J firms in the post-merger period. Simplifying the necessary conditions for firm 1 and firm 3 to J suggests the same relation of each firm's equilibrium price and product characteristics with its market share as in the pre-merger period. In another way to say that, equations (12) and (13) stay the same pre- and post-merger for both firm 1 and firm 3 to firm J.

In order to tell how the post-merger market share changes for each firm, we first take the ratio of each firm's market share with respect to the market share

of the outside option

$$\frac{S_{jt}}{S_{0t}} = \exp\left(\sum_{k=1}^{K} \beta_k Z_{jkt} - \alpha P_{jt} + \xi_j + \xi_{jt}\right), \tag{14}$$

for $j = \{1, ..., J\}$. We then apply equations (12) and (13) to substitute each firm's price P_{jt} and product characteristics Z_{jt} as a function of its market share S_{jt}

$$\frac{S_{jt}}{S_{0t}} = \exp\left[NS_{jt}\sum_{k=1}^{K} \frac{\frac{\beta_k}{\alpha} - \gamma_{jk}}{\delta_{jk}}(\beta_k - \alpha\gamma_{jk}) - \frac{1}{1 - S_{jt}}\right] M_{jt}, \tag{15}$$

where

$$M_{jt} = \exp\left[\sum_{k=1}^{K} \frac{\theta_{jt}}{\delta_{jk}}(\alpha\gamma_{jk} - \beta_k) - \alpha\omega_{jt} + \xi_j + \xi_{jt}\right]. \tag{16}$$

Solving equation (15) for each firm suggests a positive relation of each firm's market share with the market share of the outside option (Appendix Note 3). In other words, equation (15) suggests that there exists a strictly increasing function that characterizes the market share of each firm as a function of the market share of the outside option, i.e. $S_{jt} = f_{jt}(S_{0t})$, where $f'_{jt}(S_{0t}) > 0$ for $j = \{1, ..., J\}$.

Recall that the above relation is the same in both the pre- and post-merger periods. We then combine the above relation with the market share conditions in both the pre- and post-merger periods to characterize the direction of changes of firms' post-merger market shares.

In the pre-merger period, there are J firms existing in the market. Hence the

market share condition requires that

$$(17) \qquad S_{0t}^{pre} + f_{1t}(S_{0t}^{pre}) + f_{2t}(S_{0t}^{pre}) + ... + f_{Jt}(S_{0t}^{pre}) = 1.$$

Based on equation (15), we know that the left hand side of equation (17) is a strictly increasing function in S_{0t}. Therefore, solving the above equation can uniquely determine the equilibrium market share of the outside option pre-merger, i.e. S_{0t}^{pre*}. We can then recover the equilibrium market share of each firm pre-merger accordingly, i.e. $S_{jt}^{pre*} = f_{jt}(S_{0t}^{pre*})$ for $j = \{1, ..., J\}$. Recall that since the relation of the equilibrium market share, price and product characteristics remain the same pre- and post-merger for firm 1 and firm 3 to firm J, the function $S_{jt}^{*} = f_{jt}(S_{0t}^{*})$ shall remain the same pre- and post-merger for those firms. After the merger, the product of firm 2 is no longer in the market. Thus in the post-merger period, the market share condition becomes

$$(18) \qquad S_{0t}^{post} + f_{1t}(S_{0t}^{post}) + f_{3t}(S_{3t}^{post}) + ... + f_{Jt}(S_{Jt}^{post}) = 1.$$

Given that $S_{2t}^{*} = f_{2t}(S_{0t}^{*})$ is a strictly increasing function in S_{0t}, we know that the equilibrium market share for the outside option is bigger in the post-merger period, i.e. $S_{0t}^{post*} > S_{0t}^{pre*}$ (Appendix Note 4). The market shares of firm 1 and firm 3 to firm J shall also increase post-merger, i.e. $S_{jt}^{post*} > S_{jt}^{pre*}$ for $j = \{1, 3, ..., J\}$.

To conclude this section, we find that if the merged firm decides to keep only one product post-merger, then the post-merger market shares increase for the outside option, the merged and non-merging firms. We shall apply

this conclusion together with firms' necessary conditions to understand the merger's effect on post-merger product prices and characteristics for both the merged and non-merging firms in the later section.

2.5. *Prediction of Post-merger Prices and Product Characteristics*

Knowing the changes of firms' post-merger market shares, we can predict the changes of post-merger prices and product characteristics for both the merged and non-merging firms based on equations (12) and (13). Equation (13) characterizes the relation of the k-th product characteristic with respect to the firm's market share. Knowing the demand and supply sides of the market and the changes of post-merger market shares enables the prediction of post-merger product characteristics for each firm.

Based on equation (13), we see a linear relation of firm j's product characteristics Z_{jkt} with its market share S_{jt}, for $k = \{1, ..., K\}$. Thus the derivative of firm j's k-th product characteristic with respect to its market share is

$$\frac{dZ_{jkt}}{dS_{jt}} = N\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}}, \tag{19}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$. For each firm j, the derivative implies the direction of change for firm j's k-th post-merger product characteristic together with its market share. If $\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}} > 0$, then $\frac{dZ_{jkt}}{dS_{jt}} > 0$, and the k-th post-merger product characteristic and market share shall move in the same direction. On the other hand, if $\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}} < 0$, then $\frac{dZ_{jkt}}{dS_{jt}} < 0$, and the k-th post-merger product characteristic and market share shall move in the opposite direction. It is reasonable to assume that the marginal fixed cost

coefficient δ_{jk} is positive, thus the change of direction for firm j's k-th post-merger product characteristic is determined by the term of $\alpha^{-1}\beta_k - \gamma_{jk}$. In essence, the term $\alpha^{-1}\beta_k$ quantifies the relative benefit of improving the k-th product characteristic relative to price. The term γ_{jk} indicates the marginal cost of improving the k-th product characteristic for one unit. Therefore, the term $\alpha^{-1}\beta_k - \gamma_{jk}$ measures the net benefit of firm j to increase its k-th product characteristic for one unit. We thereby propose the following definition.

Definition 2.1 The *net benefit* of firm j to increase its k-th product characteristic for one unit is defined as

$$b_{jk} = \alpha^{-1}\beta_k - \gamma_{jk}, \tag{20}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$. If $b_{jk} > 0$, the firm would like to increase its k-th product characteristic when its post-merger market share becomes larger. If $b_{jk} < 0$, the firm would like to decrease its k-th product characteristic when its post-merger market share becomes larger. For the firm with a better production technology, γ_{jk} is smaller and the net benefit to increase its k-th product characteristic is more likely to be positive. Thus the firm is more likely to increase its k-th product characteristic when it expands the market share. For the firm with an inefficient production technology, γ_{jk} will be bigger and the net benefit to increase its k-th product characteristic term is more likely to be negative. Thus it may be too costly for the firm to improve its k-th product characteristic and the post-merger product characteristic would move in the opposite direction with the market share. Moreover, if the merger happens in

the market with consumers valuing more of the k-th product characteristic or being less sensitive to price, then $\alpha^{-1}\beta_k$ is more likely to be bigger and b_{jk} is more likely to be positive. In this case, the post-merger k-th product characteristic is more likely to improve together with the post-merger market share. If the merger happens in the market with consumers valuing less of the k-th product characteristic or being more sensitive to price, then $\alpha^{-1}\beta_k$ is more likely to be smaller and b_{jk} is more likely to be negative. In this case, the post-merger k-th product characteristic is more likely to move in the opposite direction with the post-merger market share.

Once the changes of firm j's post-merger market share and product characteristics are known, we can then predict the change of firm j's post-merger product price by equation (12). Equation (12) characterizes a non-linear relation of firm j's product price with its market share. We shall first denote the marginal cost and the markup term for each firm as

$$mc_{jt} = S_{jt}N\sum_{k=1}^{K}\gamma_{jk}\left(\frac{\frac{\beta_k}{\alpha}-\gamma_{jk}}{\delta_{jk}}\right) - \sum_{k=1}^{K}\frac{\theta_{jt}\gamma_{jk}}{\delta_{jk}} + \omega_{jt}, \tag{21}$$

$$\sigma_{jt} = \frac{1}{\alpha(1-S_{jt})}. \tag{22}$$

The price of firm j can therefore be written as a combination of the two terms: marginal cost and markup terms.

$$P_{jt} = mc_{jt} + \sigma_{jt}. \tag{23}$$

Based on equation (21), we find that there is a linear relation of the firm's

marginal cost with its market share. Thus whether firm j's marginal cost increases or not with the market share is determined by the term $\sum_{k=1}^{K} \gamma_{jk} \frac{(\frac{\beta_k}{\alpha} - \gamma_{jk})}{\delta_{jk}}$, which measures the overall production efficiency of firm j. Moreover, based on equation (22), there is a non-linear relation of the firm's mark up with its market share. A higher market share always suggests a higher markup for the firm. We shall propose the following definition.

Definition 2.2 The *overall production efficiency* of firm j is defined as

$$b_j = \sum_{k=1}^{K} \gamma_{jk} \frac{(\frac{\beta_k}{\alpha} - \gamma_{jk})}{\delta_{jk}}. \tag{24}$$

When $b_j > 0$, increasing firm j's market share shall increase the marginal cost for the firm, i.e. $\frac{dmc_{jt}}{dS_{jt}} > 0$. The increase in firm j's market share shall also give the firm a higher market power and thus increase its markup, i.e. $\frac{d\sigma_{jt}}{dS_{jt}} > 0$. In that case, both the marginal cost and markup effects work in the same direction. The price shall increase with a higher market share of firm j, i.e. $\frac{dP_{jt}}{dS_{jt}} > 0$. On the other hand, when $b_j < 0$, the marginal cost and markup effects work in the opposite direction and whether the post-merger price increases or not shall depend on which effect dominates. To tell which effect dominates, we shall derive the slope of change of firm j's price as a function of its market share

$$\frac{dP_{jt}}{dS_{jt}} = N \sum_{k=1}^{K} \gamma_{jk} \left(\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}} \right) + \frac{1}{\alpha(1 - S_{jt})^2}. \tag{25}$$

For $b_j < 0$, we know that the marginal cost effect is negative and the markup

effect is positive, i.e. $\frac{dmc_{jt}}{dS_{jt}} < 0$ and $\frac{d\sigma_{jt}}{dS_{jt}} > 0$. If the marginal cost effect dominates, $\frac{dP_{jt}}{dS_{jt}} < 0$ and the post-merger product price moves in the opposite direction with the market share. If the markup effect dominates, $\frac{dP_{jt}}{dS_{jt}} > 0$ and the post-merger product price moves in the same direction with the market share. From equation (25) above, whether $\frac{dP_{jt}}{dS_{jt}}$ is positive or negative depends on the overall production efficiency term b_j and the pre-merger market share of firm j. We then calculate the threshold market share S_j^c that makes $\frac{dP_{jt}}{dS_{jt}} = 0$ and hence propose the following definition.

Definition 2.3 The *threshold market share* of firm j such that $\frac{dP_{jt}}{dS_{jt}} = 0$ is defined as

$$S_j^c = 1 - \left[\frac{1}{-N\alpha b_j}\right]^{\frac{1}{2}}. \tag{26}$$

When $b_j < 0$ and $S_{jt} > S_j^c$, the markup effect dominates, and the post-merger price shall increase with the market share. On the other hand, when $b_j < 0$ and $S_{jt} < S_j^c$, the markup effect is too weak to offset the marginal cost effect, and the post-merger price shall decrease with the market share. The higher the market share of firm j, the more likely the post-merger price will increase. In addition, when $b_j > 0$, both effects work in the same direction, and the price shall increase with the market share regardless of the pre-merger market share.

To summarize, we can predict changes of firms' post-merger market shares, prices and product characteristics by knowing the pre-merger market shares, the net benefits for adjusting product characteristics b_{jk} (Definition 2.1); the

overall production efficiencies b_j (Definition 2.2); and the threshold market shares S_j^c that balance the marginal cost and markup effects (Definition 2.3). The generalized conditions and predictions of post-merger outcomes shall be rigorously presented in the main theorem; c.f. Theorem 3.1 in Section 3.

3. GENERALIZED THEOREM FOR POST-MERGER PREDICTION

Now we shall present the main theorem by generalizing conditions for post-merger predictions of firms' market shares, product characteristics, and prices under the assumptions that there are no consumers' preference changes and cost efficiency gains post-merger.

THEOREM 3.1 *Let b_{jk} be firm j's net benefit of improving its k-th product characteristic defined by Definition 2.1, b_j be firm j's overall production efficiency defined by Definition 2.2 and S_j^c be firm j's threshold market share such that $\frac{dP_{jt}}{dS_{jt}} = 0$ defined by Definition 2.3.*

1. *If $b_{jk} > 0$, firm j's market share and k-th product characteristic shall increase post-merger.*
2. *If $b_{jk} < 0$, firm j's market share shall increase post-merger and k-th product characteristic shall decrease post-merger.*
3. *If $b_j > 0$, firm j's market share and price shall increase post-merger.*
4. *If $b_j < 0$, and $S_{jt} > S_j^c$, firm j's market share and price shall increase post-merger.*
5. *If $b_j < 0$, and $S_{jt} < S_j^c$, firm j's market share shall increase post-merger, and price shall decrease post-merger.*

There are a number of implications of Theorem 3.1 that we shall discuss.

Remark 1 Knowing that the firms' market shares increase post-merger, we could predict the changes in firms' post-merger product characteristics and prices by knowing the signs of the derivative terms, i.e. $\frac{dZ_{jkt}}{dS_{jt}}$ and $\frac{dP_{jt}}{dS_{jt}}$ for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$. For each product characteristic, the sign of change in the k-th product characteristic to the market share, i.e. $\frac{dZ_{jkt}}{dS_{jt}}$, is the same as the sign of the net benefit term, i.e. $b_{jk} = \alpha^{-1}\beta_k - \gamma_{jk}$, defined by Definition 2.1. We find that whether the term b_{jk} is negative or positive depends on the firm's marginal cost of production and the consumer's preferences over price and the k-th product characteristic. When firm j is sufficiently efficient with its production of the k-th product characteristic, the term b_{jk} is more likely to be positive, and hence the firm will increase its k-th product characteristic together with the market share post-merger. When firm j is not sufficiently efficient with its production of the k-th product characteristic, increasing the product characteristic would be too costly and b_{jk} is more likely to be negative. Hence the firm would like to decrease its product characteristic when the market share increases post-merger. Moreover, when the merger involves consumers who value more of the k-th product characteristic and/or who are less sensitive to the product price, b_{jk} is more likely to be positive and the post-merger product characteristic is more likely to improve with the post-merger market share. When the merger involves consumers who value less of the k-th product characteristic and/or who are more sensitive to the product price, b_{jk} is more likely to be negative and the post-merger product characteristic is more likely to decrease with the post-merger market share.

Remark 2 The condition gets more complicated for post-merger prices.

When the firm's overall production efficiency is positive, i.e. $b_j > 0$, both the marginal cost and markup effects are positive, and the post-merger price shall increase when the firm's post-merger market share increases. In that case, the positive correlation holds regardless of firm j's pre-merger market share. If the firm's overall production efficiency is negative, i.e. $b_j < 0$ and firm j has a small market share pre-merger, i.e. $S_{jt} < S_j^c$, the positive markup effect is too small to offset the negative marginal cost effect, and hence the overall effect is negative, i.e. $\frac{dP_{jt}}{dS_{jt}} < 0$. In that case, the post-merger price shall decrease when the post-merger market share increases for firm j. On the other hand, when the overall production efficiency term is negative, i.e. $b_j < 0$ but firm j's pre-merger market share is sufficient, i.e. $S_{jt} > S_j^c$, the firm has a big market power to induce a higher markup effect. In that case, the markup effect will dominate, and the post-merger price shall decrease with the market share.

To summarize, the post-merger changes of firm j's market share, as well as price and product characteristics are endogenously determined by the firm's pre-merger market share, the firm's net benefit of increasing the product characteristic terms, i.e. b_{jk}, the firm's overall production efficiency term, i.e. b_j, and the threshold market share term that balances the marginal cost and the markup effects, i.e. S_j^c.

3.1. *Prediction of Post-merger Outcomes*

Applying the theorem above, we can predict the post-merger changes of market shares, product characteristics, and prices for both the merged and non-merging firms. We shall list the conditions required for all possible post-

merger outcomes. The conditions are based on the pre-merger equilibrium market shares, and the demand and supply side parameters characterized by b_{jk} in Definition 2.1, b_j in Definition 2.2 and S_j^c in Definition 2.3. To implement the theorem, we shall apply the theorem to consider the market with three major firms existing pre-merger, with one key product characteristic for each firm. Table I summarizes the predictions of all possible post-merger market outcomes under different conditions. In particular, Table I characterizes the conditions required for all possible changes of post-merger market shares, prices and product characteristics for both the merged and non-merging firms. Note that for $k = 1$, b_{j1} and b_j terms have the same sign. Thus the signs of b_{j1} and S_j^c are sufficient to predict the post-merger outcomes.

From Table I, the post-merger market shares shall increase for both firm 1 and firm 3. The changes in post-merger prices and product characteristics, however, can go either way, depending on firm j's net benefit of improving the major product characteristic relative to price, i.e. b_{j1} and the threshold market share that balances the marginal cost and markup effects, i.e. S_j^c. When b_{j1} is positive, both the price and product characteristic shall increase with the market share. When b_{j1} is negative, the post-merger product characteristic shall move in the opposite direction with the market share. The post-merger price shall move in the same direction with the post-merger market share if the pre-merger market share is big enough, $S_{jt} > S_j^c$ so that the positive markup effect dominates the negative marginal cost effect. For the firm with a small pre-merger market share, i.e. $S_{jt} < S_j^c$, the merger may cause a decrease of the post-merger price with the market share, as the negative marginal cost effect

dominates the positive markup effect.

4. DATA DESCRIPTION AND THE U.S. AIRLINE INDUSTRY

4.1. *The U.S. Airline Industry*

To test the proposed theorem, we shall apply the theorem to the application of the U.S. airline industry. There are a number of reasons to choose the U.S. airline industry. First, several U.S. airlines have merged in the past few years, with the well-known ones including the mergers of

- Delta and Northwest Airlines in 2008;
- United and Continental Airlines in 2010;
- Air Tran Airways and Southwest Airlines in 2010;
- American Airlines and U.S. Airways in 2013.

Second, there are publicly available data sources of the U.S. airline industry from the Bureau of Transportation Statistics. The availability of both pre- and post-merger data enables the prediction of post-merger outcomes applying the pre-merger estimation and the comparison of the theorem prediction with the actual observed post-merger outcomes. Finally, the airline industry serves as a critical component of domestic, overseas, commercial, and social functions. It counts for around 5% of the U.S. GDP and has created 10 million job opportunities.

In this paper, we shall study the merger of United and Continental Airlines in October 2010. The merger makes United Airline surpass Delta Airline as the world's largest carrier at that time. The merger was approved in October 2010. After the approval, however, United and Continental Airlines still operated separately until March 2012, when Continental Airline changed its name

to United and completely merged the operation system and the technology with United. Given the longer timespan needed for product characteristics to adjust, we shall look at the four quarters after Q1 2012 as the post-merger period. Although we may be aware that the complete adjustment of product characteristics may take longer, it would be a good time to look at, given that the merger of American Airline and U.S. Airway on Dec 9th, 2013 would complicate the whole picture. We use the four quarters from Q4 2009 to Q3 2010 as the pre-merger period, being aware that it may include some merger effect from the 2008 merger of Delta and Northwest Airlines, and the 2010 merger of Air Tran Airways and Southwest Airlines.

For the merger of United and Continental Airlines in 2010, we shall focus the study on the routes that overlap for the two merged airlines, with the total number of passengers exceeding ten thousand. We look at the pre-merger periods and find there are 8 overlapping airport pairs/16 origin-dest one-way routes that both United and Continental Airlines serve. We shall summarize the pre-merger number of passengers and the conditional market shares for those 16 overlapping routes in Table II.

For those 16 overlapping routes, both United and Continental Airlines have significant market shares. And for the two-way routes of SFO-IAH, EWR-SFO and EWR-DEN, United and Continental Airlines are the only two operation carriers, and hence obtain monopoly power on those routes. We expect the merger may have an effect on the non-overlapping routes as well, and we shall leave this concern to future work.

4.2. *Data Description*

In this paper we use the data from the Bureau of Transportation Statistics, which contains disaggregated level data from the demand and supply sides of the U.S. airline industry. The primary datasets for our empirical study include the Airline Origin and Destination Survey, T-100 Domestic Segment Data, and Airline Fuel Cost and Consumption Data. We construct the average airfare per mile using the Airline Origin and Destination Survey, and the flight frequency using the T-100 Domestic Segment Data. Besides, we use the Airline Fuel Cost and Consumption Data to calculate the fuel cost per gallon for each airline. The datasets are summarized in Table III.

5. IDENTIFICATION STRATEGY

This section addresses the identification strategy for estimating the demand and supply sides of the U.S. airline industry. We shall use the estimation results to predict post-merger outcomes applying Theorem 3.1. We shall discuss the identification strategy and the choices of instrument variables for the demand and supply side estimation. The estimation results and the comparison of predicted post-merger changes with real observed post-merger changes shall be shown in the later sections.

5.1. *Demand Estimation*

To estimate the demand side of the airline market, we shall first form the consumer's utility function. We shall define one origin-destination airport pair as one submarket and the flight offered by each airline as one product in the submarket. Thus, consumer i's utility of choosing airline j on submarket r at

time t is defined as

$$U_{ijrt} = \beta Z_{jrt} - \alpha P_{jrt} + \xi_j + \xi_{jrt} + \varepsilon_{ijrt}, \tag{27}$$

where Z_{jrt} is the product characteristic of flight j and P_{jrt} is the airfare of flight j. Both product characteristics and prices are endogenously chosen by airlines. In line with much existing literature and the Federal Aviation Administration, we shall use the flight frequency as the major product characteristic of the airline industry [28, 27]. On each submarket, either the airfare per trip or airfare per mile shall be equally informative for consumers to make purchase decisions. We shall use the airfare per mile as the flight price measure, as the coefficient excludes the distance's effect on airfare. For both choices of flight frequency and airfare per mile measures, please refer to the detailed justification in the Appendix.

We shall consider three airlines existing pre-merger, United, Continental, and all rest of the airlines will be in the other category. To use consistent notation with Theorem 3.1, we denote United Airline as firm 1, Continental Airline as firm 2, and all the other airlines as firm 3. ξ_j is the airline's brand effect. ξ_{jrt} is the unobserved product characteristic term that affects the consumer's utility. ε_{ijrt} is the idiosyncratic shock term and is assumed to follow T1EV distribution. To estimate the demand, we consider the four quarters from Q4 2009 to Q3 2010 as the pre-merger period. By the property of type 1 extreme value distribution, we shall estimate the consumer's utility function by the log

regression

$$\ln(\frac{S_{jrt}}{S_{0rt}}) = \beta Z_{jrt} - \alpha P_{jrt} + \xi_j + \xi_{jrt}, \tag{28}$$

where S_{0rt} is the market share of the outside option on submarket r at time t. There are many debates over how to define the outside option of the airline industry. In line with the existing literature, we use fraction of the geometric mean of the total passengers at the origin and destination airports as the total potential passengers on one submarket. The outside option shall be the total potential passengers excluding those passengers that fly between the origin and destination airports at time t.

Given that both flight frequencies and airfares are endogenously chosen by airlines, they could be potentially correlated with the unobserved product characteristic terms, ξ_{jrt}. Instrumental variables (IV) are required for both flight frequencies and airfares to obtain consistent estimation. Although the instrument variables for airfares are frequently seen in the previous work, the identification for endogenous flight frequencies and the choices of instrument variables for flight frequencies are limited in the existing work. We here propose to use the interaction of fuel cost per gallon of each airline at time t (F_{jt}) with the distance of each route (D_r) as the instruments for airfares. The interaction of fuel cost per gallon with distance acts as a proxy for the fuel cost on each route, which includes variations in time, submarket, and airline dimensions. It is sensible to assume that the higher fuel cost per route, the higher the airfare would be. For flight frequencies, we use the hub status and the population of

the origin and destination cities at each time as the instruments (H_j, P_{rt}). If the origin and/or destination airport has the airline hub or has a bigger population size, then we would expect the flight frequency to be higher for that airline in the submarket. To find a proxy for the population at the endpoint cities, we shall calculate the total passengers that fly in and out of the two endpoint airports.

5.2. *Supply Estimation*

After estimating the demand side of the airline industry, we can then recover the marginal cost for each airline on each submarket by the necessary condition

$$mc_{jrt} = P_{jrt} - \frac{1}{\alpha(1 - S_{jrt})}. \tag{29}$$

Observing the pre-merger price and market share for each airline and having estimated the consumer's utility function from the demand side, we can then recover the marginal cost for each airline in each submarket and time by equation (29) above. Different from the classical approach, we shall consider heterogeneity in firms' production technologies. Heterogenous production technologies shall play an important role in explaining firms' different merger incentives and post-merger outcomes. To estimate the airlines' marginal costs of production, we adopt a linear marginal cost functional form from the existing literature. The marginal cost for each airline on each route and time shall depend on the airline's flight frequency and the residual term

$$mc_{jrt} = \gamma_j Z_{jrt} + \omega_{jrt}, \tag{30}$$

where we expect that a higher flight frequency implies a higher marginal cost, i.e. $\gamma_j > 0$. ω_{jrt} is the residual term which could include other product characteristics and unobserved marginal cost terms. ω_{jrt} is allowed to be correlated with the major product characteristic term, Z_{jrt}. Hence instrument variables are required to obtain consistent estimation. We shall use the airlines' hub status and the population at the origin- and destination cities as the instruments for flight frequencies. After recovering each firm's marginal cost productivity, i.e. γ_j, we could then recover the value of the marginal fixed cost for each airline, route and time from the necessary condition

$$\frac{dFixed_{jrt}}{dZ_{jrt}} = (\frac{\beta}{\alpha} - \gamma_j)S_{jrt}. \tag{31}$$

Observing the pre-merger market share and having estimated the demand and marginal cost sides of the airline industry, we can then calculate the marginal fixed cost for each airport on each submarket and time. We then estimate each airline's marginal fixed costs as a function of flight frequencies. Recall that we adopt a quadratic form of firms' fixed costs

$$\frac{dFixed_{jrt}}{dZ_{jrt}} = \delta_j Z_{jrt} + \theta_{jrt}, \tag{32}$$

where we would expect a higher flight frequency implies a higher marginal fixed cost, i.e. $\delta_j > 0$. θ_{jrt} is the unobserved fixed cost term and is allowed to be correlated with the observed product characteristic term Z_{jrt}. Hence we shall apply the same set of instruments for flight frequencies. Once the estimation of the consumer's utility and firms' marginal and fixed costs are obtained, we

can then form the measures of net benefit terms and threshold market share terms. We can then apply Theorem 3.1 to predict changes in firms' post-merger market shares, prices and flight frequencies. The estimation results are shown in Section 6.

6. PRELIMINARY RESULTS

This section describes the estimation results for the 2010 merger of United and Continental Airlines. We first estimate the demand side of the airline industry by estimating the consumer's utility function. We then recover the marginal and fixed costs for each airline from the conditions shown in equations (29) and (31). Finally, the pre-merger estimation results are used to predict the post-merger outcomes according to Theorem 3.1. For the pre-merger period, we use the airline data that covers Q4 2009 to Q3 2010. In particular, we shall study the changes of market shares, average airfares and flight frequencies for United and the other airlines after the merger. We use the airline hub status and population at the origin- and end-point airports as the instruments for flight frequencies. We use the interaction of fuel cost per gallon of each airline with distance as the instruments for average airfares. The pre-merger estimation results are shown in Table IV, V, and VI.

Table IV shows the estimation results of the consumer's utility function. We shall denote β to be the coefficient of flight frequency and α to be the coefficient of airfare. From the estimation, the consumer values flight frequency and is more likely to purchase from the airline which offers more frequent flights. A higher airfare shall decrease a consumer's utility. The airline fixed effect is the highest for United Airline, and Continental Airline has the second highest.

Other airlines, on average, have the lowest fixed effect. From Table IV, we can calculate the marginal benefit of improving flight frequency relative to airfare term, i.e. β/α. We then compare the marginal benefit with the marginal cost estimated in Table V to form the net benefit term and to predict changes in flight frequencies and airfares post-merger.

Table V shows the estimation results of firms' marginal cost functions. We shall denote the marginal cost coefficient of flight frequency as γ_j, which measures how costly it is to improve flight frequency by one unit. The estimation results in Table V imply that Continental Airline has a better production technology in terms of marginal cost compared to United Airline, i.e. $\gamma_2 < \gamma_1$. The other airlines, on average, have the best production technology in terms of marginal cost compared to United and Continental Airlines. Combining these with Table IV, we can form the net benefits of improving flight frequency terms, i.e. $b_{j1} = \beta/\alpha - \gamma_j > 0$ for all three airlines. We then estimate the marginal fixed cost for each airline and the results are shown in Table VI below.

Table VI shows the estimation results of airlines' marginal fixed costs. We denote the coefficient with respect to firm j's flight frequency as δ_j. A positive coefficient shows that a higher flight frequency shall cause a higher marginal fixed cost of production. From the estimation results, the other airline has the lowest marginal fixed cost coefficient, and United Airline has the second lowest marginal fixed cost coefficient, while Continental Airline has the highest marginal fixed cost coefficient.

After estimating the demand and supply sides of the airline industry, we can

then combine the estimation results together with the pre-merger observed market shares to predict post-merger market outcomes. Using the parameter estimation from Table IV, V, and VI and combining them with the pre-merger observed market shares, we can then form the net benefit of improving the product characteristic and threshold market share terms, i.e. b_{j1} and S_j^c of each airline. The two measures together with the pre-merger levels of market shares shall be shown in Table VII below. Based on the table, we can then apply Theorem 3.1 to predict the post-merger changes of market shares, flight frequencies and airfares for United and the other airlines.

From Table VII, the net benefit of improving the product characteristic term b_{j1} is positive on all the routes for both United and the other airlines. Given $b_{j1} > 0$, we know from the theorem that $\frac{dP_{jt}}{dS_{jt}} > 0$ on all the routes regardless of the pre-merger market shares. After knowing the signs of b_{j1} and $\frac{dP_{jt}}{dS_{jt}}$, we can predict the post-merger market outcomes based on Theorem 3.1. In particular, we can predict the changes of market shares, flight frequencies and airfares for both United and the other airlines post-merger. The prediction outcomes for United and the other airlines are shown in Table VIII and IX respectively. We also compare the predicted outcomes with the actual observed post-merger outcomes in those tables.

Table VIII compares the actual observed changes in post-merger market shares, airfares and flight frequencies for United Airline with the predicted changes in those dimensions. To conduct the comparison, we use the 2010 Q3 as the pre-merger period and 2012 Q3 as the post-merger period. The last column shows the theorem predicted post-merger outcomes. Theorem 3.1

predicts that after the merger of United and Continental Airlines, the market shares, flight frequencies and average airfares shall increase on all the routes of United Airline. The second last column shows the actual observed changes of post-merger market shares, flight frequencies and airfares of United Airline. From the table, the observed post-merger outcomes match the predicted post-merger outcomes with few exceptions.

Table IX compares the actual observed changes in post-merger market shares, airfares and flight frequencies for the other airlines with the theorem predicted changes in those dimensions. The last column shows the theorem predicted post-merger market outcomes. Theorem 3.1 predicts that the post-merger market shares, flight frequencies, and average airfares shall increase on all the routes for the other airlines. The second last column shows the actual observed changes in the post-merger outcomes. We find that the observed post-merger outcomes in Table IX match the predicted post-merger outcomes with few exceptions.

We find that the few exceptions can be explained by realizing that a lot of events happened during that period besides the merger activity. In fact, by decomposing the airlines under the other category, we find that on the routes of LAX-OGG, OGG-LAX, LAX-HNL and HNL-LAX, the airlines included in the other airline category are the same pre- and post-merger, which suggests that there is no entries and exits of those airlines post-merger. However, on the routes of EWR-ORD, ORD-EWR, and ORD-IAH, IAH-ORD, we find that the entries and exits of some airlines made the other category not the same pre- and post-merger. This could potentially explain why the theorem predictions

are not accurate on those routes. In addition, the inaccurate predictions on the few exceptions could also be explained by firms' changes of marginal and fixed cost productivities, and the consumer's changes of preferences over airfares and flight frequencies post-merger.

Overall, the comparison in Table VIII and IX suggests that Theorem 3.1 has a high prediction accuracy rate of 83.3% for predicting the changes of post-merger market shares, flight frequencies, and airfares for both United and the other airlines. Hence the theorem prediction is strongly supported by the airline merger application for both the merged and non-merging airlines.

7. CONCLUSION

Different from the current merger guidelines which predict an increase in post-merger prices under the restrictive assumption that product characteristics are exogenous, this paper allows the simultaneous endogeneity of both prices and product characteristics. The paper performs the merger analysis by providing the generalized theorem to predict post-merger changes of market shares, product characteristics, and prices for both the merged and non-merging firms. The paper also makes contributions by allowing firms to be differentiated in their production technologies and studying how differentiated production technologies shall affect firms' pricing and product repositioning incentives post-merger. The paper finds that changes of firms' post-merger market outcomes depend on the consumer's utility and firms' marginal and fixed costs of production. In particular, firms' endogenous choices of post-merger market shares, product characteristics, and prices depend on the pre-merger market shares, i.e. S_{jt}, net benefits of improving product characteristics, i.e.

b_{jk}, overall production efficiencies, i.e. b_j, and threshold market shares such that $\frac{dP_{jt}}{dS_{jt}} = 0$, i.e. S_j^c. By generalizing the conditions required for different post-merger predictions, the paper provides a generalized theorem that can predict post-merger outcomes in a variety of dimensions. In addition, it helps solve some puzzles from the observed merger cases and literature and provides some new insights regarding: 1) why we do not always observe an increase in firms' post-merger prices, and 2) why the existing literature with different merger applications can arrive at opposite conclusions regarding how firms change their product characteristics post-merger.

The generalized theorem is then applied to study the 2010 merger of United and Continental Airlines. We estimate the demand and supply sides of the airline industry using the pre-merger observed data. We then predict the post-merger changes of market shares, airfares, and flight frequencies for both the merged and non-merging firms based on the parameter estimation and Theorem 3.1. Comparing the theorem predicted post-merger changes with the actual observed post-merger changes suggests that the theorem has a high prediction accuracy power for predicting post-merger outcomes for both the merged and non-merging firms. The prediction accuracy rate is 83.3%.

REFERENCES

[1] Daniel Ackerberg and Marc Rysman. Unobserved product differentiation in discrete choice models: Estimating price elasticities and welfare effects. *NBER Working Paper*, 2002.

[2] Orley C. Ashenfelter, Daniel S. Hosken, and Matthew C. Weinberg. The price effects of a large merger of manufacturers: A case study of maytag-

whirlpool. *NBER Working Paper*, 2011.

[3] Steven Berry. Estimating discrete-choice models of product differentiation. *RAND Journal of Economics*, 25, 1994.

[4] Steven Berry, James Levinsohn, and Ariel Pakes. Automobile prices in market equilibrium. *Econometrica*, 63, 1995.

[5] Steven Berry and Joel Waldfogel. Do mergers increase product variety? : Evidence from radio broadcasting. *Quarterly Journal of Economics*, 116, 2001.

[6] Dennis Carlton. Market definition: Use and abuse. *Competition Policy International*, 3, 2007.

[7] Dennis Carlton. Revising the horizontal merger guidelines. *Journal of Competition Law and Economics*, 2010.

[8] Chenghuan Sean Chu. The effect of satellite entry on cable television prices and product quality. *RAND Journal of Economics*, 41, 2010.

[9] Gregory Crawford and Matthew Shum. Empirical modeling of endogenous quality choice: the case of cable television. *working Paper*, 2001.

[10] Gregory S. Crawford. Endogenous product choice: A progress report. *International Journal of Industrial Organization*, 30, 2012.

[11] Michaela Draganska, Michael Mazzeo, and Katja Seim. Addressing endogenous product choice in an empirical analysis of merger effects. *Discussion paper, Northwestern University*, 2009.

[12] Ying Fan. Ownership consolidation and product characteristics: A study of the u.s. daily newspaper market. *American Economic Review*, 103, 2013.

[13] Shapiro Farrell. Antitrust evaluation of horizontal mergers: An economic alternative to market definition. *The B.E. Journal of Theoretical*, 2010.

[14] Amit Gandhi, Luke Froeb, Steven Tschantz, and Gregory Werden. Post-merger product repositioning. *Journal of Industrial Economics*, 56, 2008.

[15] Lisa George. What's fit to print: The effect of ownership concentration on product variety in daily newspaper markets. *Economics of the Media*, 19, 2007.

[16] Georg Gotz and Klaus Gugler. Market concentration and product variety under spatial competition: Evidence from retail gasoline. *Journal of Industrial Competition and Trade*, 6, 2006.

[17] Jacob Gramlich. Gas prices, fuel efficiency, and endogenous product choice in the u.s. automobile industry. 2009.

[18] Ken Heyer. Welfare standard and merger analysis: Why not the best? *SSRN 959454*, 2006.

[19] E. Han Kim and Vijay Singal. Mergers and market power: Evidence from the airline industry. *The American Economic Review*, 1993.

[20] Jinkook Lee. Endogenous product characteristics in merger simulation: A study of the u.s. airline industry. *working paper*, 2013.

[21] Mark. Manuszak and Charles. Moul. Prices and endogenous market structure in office supply stores. *Journal of Industrial Economics*, 2008.

[22] Michael Mazzeo. Product choice and oligopoly market structure. *Rand Journal of Economics*, 33, 2002.

[23] Michael Mazzeo. Competition and service quality in the u.s. airline industry. *Review of Industrial Organization*, 22, 2003.

[24] Michael Mazzeo, Katja Seim, and Mauricio Varela. The welfare consequences of mergers with product repositioning. *working paper*, 2013.

[25] Aviv Nevo. Measuring market power in the ready-to-eat cereal industry. *Econometrica*, 69, 2001.

[26] U.S. Department of Justice and the Federal Trade Commission. Horizontal merger guidelines. 2010.

[27] C. Peters. Evaluating the performance of merger simulation: Evidence from the u.s. airline industry. *Journal of Law and Economics*, 2006.

[28] O. Richard. Flight frequency and mergers in airline markets. *International Journal of Industrial Organization*, 2003.

[29] Katja Seim. An empirical model of firm entry with endogenous product-type choices. *Rand Journal of Economics*, 37, 2006.

[30] Kenneth Small. A discrete choice model for ordered alternatives. *Econometrica*, 55, 1987.

[31] A. Sweeting. The effects of horizontal mergers on product positioning: Evidence for the music radio industry. *RAND Journal of Economics*, 2010.

[32] Andrew Sweeting. Dynamic product repositioning in differentiated product industries: the case of format switching in the commercial radio industry. *NBER working paper*, 2007.

[33] Randal Watson. Product variety and competition in the retail market for eyeglasses. *Journal of Industrial Economics*, 57, 2009.

8. APPENDIX

8.1. *Appendix Note 1*

Derivations of the expressions for $\frac{dS_{jt}}{dP_{jt}}$, $\frac{dS_{jt}}{dZ_{jkt}}$, $\frac{dS_{jt}}{dP_{j't}}$ and $\frac{dS_{jt}}{dZ_{j'kt}}$ suggest that

$$\frac{dS_{jt}}{dP_{jt}} = S_{jt}(-\alpha)(1 - S_{jt}), \tag{33}$$

$$\frac{dS_{jt}}{dZ_{jkt}} = S_{jt}\beta_k(1 - S_{jt}), \tag{34}$$

$$\frac{dS_{jt}}{dP_{j't}} = \alpha S_{jt}S_{j't}, \tag{35}$$

$$\frac{dS_{jt}}{dZ_{j'kt}} = -S_{jt}\beta_k S_{j't}. \tag{36}$$

8.2. *Appendix Note 2*

Applying the equations in Note 1 above, the necessary conditions in equations (8) and (9) become:

$$[P_{jt}] : N(P_{jt} - mc_{jt})S_{jt}(-\alpha)(1 - S_{jt}) + NS_{jt} = 0, \tag{37}$$

$$[Z_{jkt}] : N(P_{jt} - mc_{jt})S_{jt}\beta_k(1 - S_{jt}) - N\gamma_{jk}S_{jt} - \delta_{jk}Z_{jkt} - \theta_{jt} = 0. \tag{38}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$. Simplifying the equations above suggests that

$$[P_{jt}] : P_{jt} - mc_{jt} = \frac{1}{\alpha(1 - S_{jt})}, \tag{39}$$

$$[Z_{jkt}] : NS_{jt}(\frac{\beta_k}{\alpha} - \gamma_{jk}) = \delta_{jk}Z_{jkt} + \theta_{jt}. \tag{40}$$

Simplifying equations (39) and (40) further suggests that

$$[P_{jt}] : P_{jt} = \sum_{k=1}^{K} [\gamma_{jk} N S_{jt} \left(\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}} \right) - \frac{\theta_{jt}\gamma_{jk}}{\delta_{jk}}] + \omega_{jt} + \frac{1}{\alpha(1 - S_{jt})}, \tag{41}$$

$$[Z_{jkt}] : Z_{jkt} = N S_{jt} \left(\frac{\alpha^{-1}\beta_k - \gamma_{jk}}{\delta_{jk}} \right) - \frac{\theta_{jt}}{\delta_{jk}}. \tag{42}$$

for $k = \{1, ..., K\}$ and $j = \{1, ..., J\}$.

8.3. *Appendix Note 3*

For each firm, equation (15) characterizes the relation of the market share of the outside option with the market share of firm j. We find that for any given S_{0t}, the left hand side of equation (15) is a linear function in S_{jt}. As the market share of the outside option increases, the linear line becomes flatter but is always upward sloping. The right hand side of equation (15) is a non-linear function in S_{jt}. To understand how the right hand side of equation (15) evolves with S_{jt}, we shall first denote the function in the exponential symbol to be

$$L_{jt}(S_{jt}) = N S_{jt} \sum_{k=1}^{K} [\frac{\frac{\beta_k}{\alpha} - \gamma_{jk}}{\delta_{jk}} (\beta_k - \alpha\gamma_{jk})] - \frac{1}{1 - S_{jt}}. \tag{43}$$

The derivative of $L_{jt}(S_{jt})$ with respect to S_{jt} suggests that

$$\frac{dL_{jt}(S_{jt})}{dS_{jt}} = N \sum_{k=1}^{K} (\frac{\frac{\beta_k}{\alpha} - \gamma_{jk}}{\delta_{jk}})(\beta_k - \alpha\gamma_{jk}) - \frac{1}{(1 - S_{jt})^2}. \tag{44}$$

We can tell from equation (44) above that the function $L_{jt}(S_{jt})$ shall be upward sloping in S_{jt} when S_{jt} is sufficiently small and the function $L_{jt}(S_{jt})$

shall be downward sloping in S_{jt} when S_{jt} is sufficiently big. As the value of S_{jt} gets bigger, the slope becomes less positive and/or more negative.

Based on the analysis above, we could draw the curve of the RHS of equation (15). Given its concave down shape and the y-intercept is positive, we know that the RHS shall intersect with the LHS at one point. By allowing the market share of the outside option to increase, the LHS would become flatter, and the RHS is not a function of S_{0t}. Hence the market share of firm j shall become bigger as the market share for the outside option increases. Hence we could characterize the market share of firm j as a function of the market share of the outside option, i.e. $S_{jt} = f_{jt}(S_{0t})$, which we know would be strictly increasing.

8.4. *Appendix Note 4*

Given the market share of firm j is a strictly increasing function of the market share of the outside option, the LHS of equation (17) shall be an increasing function of S_{0t}. Solving equation (17) at 1 shall return the equilibrium market share of the outside option pre-merger. For the post-merger period, the functional forms of $f_{1t}(S_{0t})$ and $f_{3t}(S_{0t})$ to $f_{Jt}(S_{0t})$ stay the same as in the pre-merger period. Given that firm 2 no longer exists in the market, we know that the LHS of equation (18) shall lie beneath the LHS of equation (17). By solving the post-merger market share condition at 1, we know that the post-merger equilibrium market share shall increase for the outside option, which also suggests the post-merger equilibrium market shares shall increase for firm 1 and firm 3 to firm J.

8.5. *Appendix Note 5*

In the study of the effective factors influencing the decision-making process of Iranian air travelers in their choice of airline for domestic flights, flight schedule/frequency was listed to be "the highest priority factors". In the Airport Cooperative Research Program sponsored by the Federal Aviatation Administration, the report claimed that "passengers generally prefer to use airports in which they have greater flexibiltiy in departure and arrival times, and they value multiple flight frequencies."

8.6. *Appendix Tables*

TABLE I

Prediction of post-merger Market Shares, Prices and Product Characteristics

Conditions		Post-merger Outcomes					
b_{11}, b_{31}	S_1^c, S_3^c	S_1	S_3	P_1	P_3	Z_1	Z_3
$b_{11} > 0, b_{31} > 0$		$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$
$b_{11} > 0, b_{31} < 0$	$S_3 > S_3^c$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$
$b_{11} > 0, b_{31} < 0$	$S_3 < S_3^c$	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$
$b_{11} < 0, b_{31} > 0$	$S_1 > S_1^c$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$
$b_{11} < 0, b_{31} > 0$	$S_1 < S_1^c$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$
$b_{11} < 0, b_{31} < 0$	$S_1 > S_1^c, S_3 > S_3^c$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\downarrow$
$b_{11} < 0, b_{31} < 0$	$S_1 > S_1^c, S_3 < S_3^c$	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\downarrow$	$\downarrow$
$b_{11} < 0, b_{31} < 0$	$S_1 < S_1^c, S_3 > S_3^c$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$	$\downarrow$
$b_{11} < 0, b_{31} < 0$	$S_1 < S_1^c, S_3 < S_3^c$	$\uparrow$	$\uparrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$

TABLE II

Passengers on overlapping Routes between UA and CO Q3 2010.

Airport Pair	Passengers			Conditional Shares		
	UA	CO	Others	UA	CO	Others
LAX-OGG	13937	1781	18018	0.413	0.053	0.534
OGG-LAX	14772	2623	19717	0.398	0.071	0.531
SFO-IAH	3041	29101	0	0.095	0.905	0
IAH-SFO	2477	29142	0	0.078	0.922	0
EWR-SFO	6199	28076	0	0.181	0.819	0
SFO-EWR	10086	28286	0	0.263	0.737	0
LAX-HNL	19613	6009	50386	0.258	0.079	0.663
HNL-LAX	20714	7278	52934	0.256	0.090	0.654
EWR-ORD	13847	21368	19844	0.251	0.388	0.360
ORD-EWR	12224	21204	21683	0.222	0.385	0.393
ORD-IAH	6654	31022	7359	0.148	0.689	0.163
IAH-ORD	5164	31362	8301	0.115	0.700	0.185
EWR-DEN	9557	12413	0	0.435	0.565	0
DEN-EWR	9630	12120	0	0.443	0.557	0
DEN-IAH	9729	23847	11572	0.215	0.528	0.256
IAH-DEN	12949	23984	10149	0.275	0.509	0.216

†Datasource: T100 Domestic Segment.

TABLE III

Data Sources.

Dataset	Variables	Sample Periods
T-100 Domestic Segment	Market Share, Frequencies Airlines	2009 Q4 - 2010 Q3 2012 Q2 - 2013 Q1
Origin and Destination Survey	Airfare, Distance	2009 Q4 - 2010 Q3 2012 Q2 - 2013 Q1
Airline Fuel Cost and Consumption	Fuel Cost	2009 Q4 - 2010 Q3 2012 Q2 - 2013 Q1

TABLE IV

Estimation Results on Parameters for Utilities Pre-merger.

Mean Utilities	Coeff	St. Error	Z	p-value	95% Conf. Interval
Frequency	2.386	0.351	6.80	0.000	[1.698, 3.074]
Airfare	0.940	0.217	4.33	0.000	[0.515, 1.365]
UA	-5.037	0.287	-17.56	0.000	[-5.600, -4.475]
CO	-5.704	0.357	-16.00	0.000	[-6.403, -5.005]
Firm3	-7.493	0.539	-13.90	0.000	[-8.549, -6.436]

†Instrumented: Airfare Frequency

†Instrumentals: ua co cost-per-gallon-distance pop-origin pop-dest hub-origin hub-dest

TABLE V

Estimation Results on Parameters for Marginal Costs Pre-merger.

Marginal Costs	Coeff	St. Error	Z	p-value	95% Conf. Interval
UA frequency	0.853	0.086	9.88	0.000	[0.684, 1.023]
CO frequency	0.703	0.051	13.90	0.000	[0.603, 0.802]
Others frequency	0.402	0.043	9.39	0.000	[0.318, 0.486]

†Instrumented: UA frequency CO frequency Others frequency

†Instruments: ua-hub-origin ua-hub-dest co-hub-origin co-hub-dest others-hub-origin others-hub-dest ua-pop-origin ua-pop-dest co-pop-origin co-pop-dest others-pop-origin others-pop-dest

TABLE VI

Estimation Results on Parameters for Fixed Costs Pre-merger.

Fixed Costs	Coeff	St. Error	Z	p-value	95% Conf. Interval
UA frequency	0.021	0.002	11.46	0.000	[0.017, 0.024]
CO frequency	0.026	0.001	25.10	0.000	[0.024, 0.028]
Others frequency	0.015	0.001	17.10	0.000	[0.013, 0.017]

†Instrumented: UA frequency CO frequency Others frequency

†Instruments: ua-hub-origin ua-hub-dest co-hub-origin co-hub-dest others-hub-origin others-hub-dest ua-pop-origin ua-pop-dest co-pop-origin co-pop-dest others-pop-origin others-pop-dest

TABLE VII

PREDICTIONS OF POST-MERGER OUTCOMES

Route	S_{1t}	S_{3t}	b_{11t}, b_{31t}	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}}$
LAX-OGG	0.413	0.534	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
OGG-LAX	0.398	0.531	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
SFO-IAH	0.095	0	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
IAH-SFO	0.078	0	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
EWR-SFO	0.181	0	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
SFO-EWR	0.263	0	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
LAX-HNL	0.258	0.663	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
HNL-LAX	0.256	0.654	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
EWR-ORD	0.252	0.360	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
ORD-EWR	0.222	0.393	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
ORD-IAH	0.148	0.163	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
IAH-ORD	0.115	0.185	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
EWR-DEN	0.435	0	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
DEN-EWR	0.443	0	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
DEN-IAH	0.216	0.256	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$
IAH-DEN	0.275	0.216	$b_{11t}, b_{31t} > 0$	$\frac{dP_{1t}}{dS_{1t}}, \frac{dP_{3t}}{dS_{3t}} > 0$

TABLE VIII

PRE- AND POST-MERGER COMPARISONS FOR UNITED AIRLINE.

	Pre-			Post-			Comparison	
Airport pair	P	Fr	S	P	Fr	S	Actual	Predicted
LAX-OGG	1.32	0.81	0.413	1.54	0.82	0.393	S ↓, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
OGG-LAX	1.43	0.81	0.398	1.55	0.81	0.391	S ↓, P ↑, Fr ↑	S ↑ P ↑ , Fr ↑
SFO-IAH	1.49	3.00	0.095	2.36	3.05	1	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
IAH-SFO	1.21	3.00	0.078	2.28	3.05	1	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
EWR-SFO	1.38	0.60	0.181	1.74	2.88	1	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
SFO-EWR	1.26	0.89	0.263	1.66	2.89	1	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
LAX-HNL	1.17	0.90	0.258	1.25	1.40	0.280	S ↑, P ↑, Fr ↑	S ↑, P ↑ , Fr ↑
HNL-LAX	1.20	0.90	0.256	1.29	1.41	0.288	S ↑, P ↑, Fr ↑	S ↑, P ↑ , Fr ↑
EWR-ORD	3.74	0.15	0.252	4.04	3.63	0.744	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
ORD-EWR	3.66	0.12	0.222	4.17	3.85	0.789	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
ORD-IAH	2.64	0.84	0.148	3.88	3.13	0.878	S ↑, P ↑, Fr ↑	S ↑, P ↑ , Fr ↑
IAH-ORD	2.72	0.63	0.115	3.80	3.37	0.880	S ↑, P ↑, Fr ↑	S ↑, P ↑ , Fr ↑
EWR-DEN	1.80	0.82	0.435	1.73	2.02	0.759	S ↑, P ↓, Fr ↑	S ↑, P ↑, Fr ↑
DEN-EWR	1.86	0.83	0.443	1.72	1.94	0.752	S ↑, P ↓, Fr ↑	S ↑, P ↑, Fr ↑
DEN-IAH	2.13	0.89	0.216	3.27	2.77	0.869	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
IAH-DEN	2.15	0.11	0.275	3.16	2.87	0.897	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑

†S:share; F: frequency; P: price.

TABLE IX

PRE- AND POST-MERGER COMPARISONS FOR OTHER AIRLINES.

	Pre-			Post-			Comparison	
Airport pair	P	Fr	S	P	Fr	S	Actual	Predicted
LAX-OGG	1.37	1.21	0.534	1.47	1.32	0.607	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
OGG-LAX	1.38	1.20	0.531	1.49	1.32	0.609	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
LAX-HNL	1.16	2.69	0.663	1.31	3.00	0.721	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
HNL-LAX	1.18	2.67	0.654	1.32	2.98	0.712	S ↑, P ↑, Fr ↑	S ↑, P ↑, Fr ↑
EWR-ORD	3.20	3.35	0.360	3.67	2.53	0.257	S ↓, P ↑, Fr ↓	S ↑, P ↑, Fr ↑
ORD-EWR	3.18	3.38	0.393	3.56	2.12	0.211	S ↓, P ↑, Fr ↓	S ↑, P ↑, Fr ↑
ORD-IAH	2.56	1.53	0.163	2.96	1.09	0.122	S ↓, P ↑, Fr ↓	S ↑, P ↑, Fr ↑
IAH-ORD	2.51	1.74	0.185	3.08	1.09	0.120	S ↓, P ↑, Fr ↓	S ↑, P ↑, Fr ↑

†S:share; F: frequency; P: price.