ABSTRACT. If there is price discrimination, at least one of the prices is not equal to marginal cost. Therefore, if there is price discrimination, there must be market power. While this logic is sound, it has led many policy-makers to believe that price discrimination and market power are positively correlated. We present a model where measured price discrimination can be low while market power is high, and price discrimination can be high while market power is low, thus demonstrating that there is no theoretical connection between the strength of price discrimination and that of market power. We then present new evidence that price discrimination is negatively correlated with market power in the US airlines industry. (JEL L41 L93)
Price discrimination is commonly viewed as an indication of market power. Disadvantaged buyers, who realize that a firm is charging them a higher, and seemingly more profitable, price than it is charging similar buyers for the same good, are naturally given to protest and accuse the firm of monopoly. Economists, on the other hand, have a less emotional reason to view price discrimination as indicative of market power. In a competitive market, price equals marginal cost. Wherever there is price discrimination, at least one of the prices deviates from marginal cost. Therefore, if there is price discrimination, there must be market power (see, for example, Varian, 1989, and Stole, 2003). Antitrust scholars have employed similar logic:

Persistent price discrimination is very good evidence of market power because it is inconsistent with a competitive market; it implies that some consumers are paying more than the cost of serving them, a situation that would disappear with competition. (Posner, 1990, p. 63)

Policy makers are inevitably tempted to infer from logic of this kind that price discrimination and market power are strongly positively correlated, i.e., high price discrimination indicates high market power, while low price discrimination indicates low market power. Thus, they tend to impose antitrust remedies when they find evidence of highly discriminatory price structures, and to dismiss antitrust charges when they find that price structures are relatively uniform.¹

The purpose of this paper is to study the extent to which price discrimination is a faithful indicator of the extent of market power. In the first part of the paper, we propose a Hotelling price-competition model, involving a monopolist selling a product differentiated from that of a competitive fringe. We provide plausible conditions under which measured price discrimination is low while market power can be high, and plausible conditions under which price discrimination is high while market power is low.

¹ See, for example, Coal Exporters Ass’n v. U.S., 745 F.2d 76, 91 (D.C. Cir. 1984) (“it is well established that the ability of a firm to price discriminate is an indicator of significant market power”); and U.S. v. Eastman Kodak Co., 63 F.3d 95, 106 & n.6 (2nd Cir. 1995) (“The theory that price discrimination is one of the indicia of market power… has received acceptance in the academic community). In the case of U.S. v. Microsoft, expert witnesses for the government repeatedly testified that substantial price discrimination in OS prices to Microsoft’s principal customers, computer manufacturers, is an indicator of Microsoft’s considerable market power (see part C, sections 38.2 and 38.3, of U.S. v. Microsoft: Proposed Findings of Fact, at http://www.usdoj.gov/atr/cases/f2600/2613a_htm.htm).
thus severing any theoretical connection between the strength of price discrimination and that of market power.

Several authors have claimed that price discrimination can exist without market power. To show this, they extend the basic model of price discrimination in different directions. Locay (1992) introduces group purchases, Levine (2002) introduces common costs, and Dana (1998) introduces information differences and advance purchase discounts. However, information differences give rise to market power, and differences in product offerings are not necessarily price discrimination. Strictly speaking, price discrimination cannot occur without market power.

In a recent symposium, Baker (2003), Baumol and Swanson (2003), Hurdle and McFarland (2003), Klein and Wiley (2003a, 2003b) and Ward (2003) address the relationship between price discrimination and long-run market power. Price discrimination can arise in markets without entry barriers where firms have no long run market power, as long as they have short run market power. Consider a Cournot model where firms are quantity-competing over a homogeneous good in several distinct segments of a market with a fixed production cost but no entry barriers. In this setting, entry eventually drives long-run economic profits and market power to zero, but the fixed entry cost nevertheless guarantees short-run market power, prices above marginal cost, and distinct equilibrium prices in different market segments (see Stole, 2003, section 3.2, for an elegant discussion of this model).

Thus, price discrimination is not a good proxy for long-run market power. The analysis in this paper implies that price discrimination is not a good proxy for the extent of short-run market power either. While economists may be more concerned with the long run, the short-run often matters greatly for antitrust authorities and the public.

In the second part of the paper, we provide evidence that price discrimination is not positively correlated with market power in the US airlines industry. In the sample of hub-to-spoke airport city pairs that we analyze, we find that price discrimination by hub carriers is generally higher in the spoke-to-hub markets, where the market power of hub carriers is lower, than in the hub-to-spoke markets, where their market power is higher. Thus price discrimination and market power are negatively correlated in the U.S. airlines industry, which confirms empirically the possibility raised by our theoretical finding.
II. THEORY

The model’s actors are a discriminating monopolist and numerous competitive fringe firms. Customers are uniformly located on the [0,2] segment. The monopolist is located at \( x_m = 0 \), while the competitive fringe is located at the other end of the segment, i.e., \( x_f = 2 \). A firm must incur transportation cost \( C(x) \) to serve a customer located at a distance \( x \) from it. \(^2\)

Given that the prices of fringe firms, \( p_f \), are set at the competitive level, \( C(2-x) \), the monopolist’s profit-maximizing prices solve the following program:

\[
\begin{align*}
\max_p & \quad p - C(x) \\
\text{s.t.} & \quad p \leq p_f = C(2-x)
\end{align*}
\]

The resulting set of optimal prices is

\[
p_m = \begin{cases} 
C(2-x) & \text{if } C(x) \leq C(2-x) \\
C(2-x) + \varepsilon & \text{otherwise}
\end{cases}
\]

for any \( \varepsilon > 0 \). In equilibrium, the monopolist supplies half of the market, i.e., \( x_m^* = 1 \).

This model is an appropriate vehicle for looking at the connection between price discrimination and market power because it allows a distinction between price differences due to cost differences and price differences due to differences in market power. \(^3\)

The measure of the mean mark-up (market power) of the monopolist is:

\[
\mu \equiv \int_0^1 C(2-x) - C(x) \, dF(x)
\]

How much price discrimination is a lot of price discrimination? Consider the definition of the extent of price discrimination that is the standard deviation of markups:

\[
\sigma \equiv \sqrt{\int_0^1 (C(2-x) - C(x))^2 \, dF(x) - \left( \int_0^1 (C(2-x) - C(x)) \, dF(x) \right)^2}.
\]

This measure of price discrimination makes the conventional wisdom true—an increase

---

\(^2\) One can interpret the [0,2] segment as physical or characteristic space, and \( C(x) \) as the costs of shipping the product to customers located at different points in physical space or the costs of tailoring it to customers located at different points in characteristic space.

\(^3\) Variations of this model are common in the literature on spatial discrimination (see, for example, Tirole, 2002, p. 140).
in market power (μ) through a scalar \( \gamma \) will generally go with an increase in price discrimination:

\[
\sigma(\gamma) = \frac{\left( 1 \int_0^1 (\gamma C(2-x) - \gamma C(x))^2 \, dF(x) - (\int_0^1 (\gamma C(2-x) - \gamma C(x)) \, dF(x))^2 \right)}{\left( \int_0^1 (C(2-x) - C(x))^2 \, dF(x) - (\int_0^1 (C(2-x) - C(x)) \, dF(x))^2 \right)}
\]

\[
= \frac{\gamma^2}{\left( \int_0^1 (C(2-x) - C(x))^2 \, dF(x) - (\int_0^1 (C(2-x) - C(x)) \, dF(x))^2 \right)} = \gamma \sigma
\]

(5)

However, the definition of price discrimination as the standard deviation in the markups makes price discrimination increase with inflation, a flaw in the definition. To overcome this problem, we can measure price discrimination in percent—how much do prices vary relative to the average prices? Specifically, we use the coefficient of variation (CV) of markups, which is the standard deviation of markups divided by the mean markup to measure the level of price discrimination:

\[
CV = \frac{\sigma}{\mu} = \frac{\left( 1 \int_0^1 (C(2-x) - C(x))^2 \, dF(x) - (\int_0^1 (C(2-x) - C(x)) \, dF(x))^2 \right)}{\left( \int_0^1 (C(2-x) - C(x))^2 \, dF(x) - (\int_0^1 (C(2-x) - C(x)) \, dF(x))^2 \right)} - 1
\]

(6)

This definition of the extent of price discrimination has advantages. It is invariant to linear transformations of the cost function, so an increase in the price level does not affect the measured extent of price discrimination. It is invariant to an increase in costs that are fully passed on to consumers. For any scaling factor \( \gamma > 0 \),

\[
CV(\gamma) = \frac{\left( 1 \int_0^1 (\gamma C(2-x) - \gamma C(x))^2 \, dF(x) - (\int_0^1 (\gamma C(2-x) - \gamma C(x)) \, dF(x))^2 \right)}{\left( \int_0^1 (\gamma C(2-x) - \gamma C(x))^2 \, dF(x) - (\int_0^1 (\gamma C(2-x) - \gamma C(x)) \, dF(x))^2 \right)} - 1 = CV
\]

(7)

On the other hand, the mean mark-up \( \mu \) changes as the level of \( \gamma \) changes. In particular, \( \mu \) is an increasing function of \( \gamma \):

\[
\mu(\gamma) = \int_0^1 \gamma C(2-x) - \gamma C(x) \, dF(x) = \gamma \mu
\]

(8)

Therefore, for a given level of price-discrimination (constant CV), the mean mark-up can be low or high depending on the level of \( \gamma \). As \( \gamma \to 0 \), the monopolist’s mark-up diminishes while the level of price-discrimination—the variation in markups—remains the same. Figure 1 illustrates the effect for a linear cost function.
Any linear reduction in cost reduces the mark-up proportionally, but not the CV, because the CV measures dispersion relative to the level of the mean mark-up. A decrease in the mark-up also decreases price dispersion. But the decrease in the dispersion in prices is exactly the same as the decrease in the mean mark-up, so that relative price dispersion is intact.

The parameter $\gamma$ can be interpreted as the degree of substitutability between the products of the monopolist and the fringe. If customers located near the monopolist prefer the monopolist’s product over the fringe’s product only a little more than do customers located near the fringe, i.e., customers are almost identical, then the fringe incurs almost the same cost to tailor its product to the customers near the monopolist as it incurs to tailor its product to customers right next store. This would naturally reduce the monopolist’s power to set price above cost. On the other hand, if the fringe finds it more costly to tailor its own product to the characteristics of customers located near the monopolist, i.e., customers are very distinct in their tastes, then $\gamma$ is larger and the monopolist is able to charge a price with a higher mark-up for any given level of price-discrimination.

As consumers become more identical, market power vanishes while price discrimination remains large. It is also possible for profits to remain large while price discrimination vanishes. To see this, consider an industry where firms have access to
more than one cost technology. Firms can optimize production by choosing a convex combination of technologies that minimizes the cost of production with respect to the level of output. For simplicity, assume that two types of technologies are available, \( c_1(x) \) and \( c_2(x) \). A firm’s cost minimization problem is characterized by \( C(x) = \min\{c_1(x), c_2(x)\} \). Suppose there exists a level of output \( \bar{x} > 0 \) that induces the following cost minimization behavior by firms:

\[
C(x) = \begin{cases} 
    c_1(x) & \text{for } x \leq \bar{x} \\
    c_2(x) & \text{for } x > \bar{x} 
\end{cases}
\]  

(9)

Figure 2 illustrates a case where the first technology, \( c_1(x) \), is increasing in the shipping distance \( x \), and increasing at an increasing rate, that is \( c'_1(x) \geq 0 \) and \( c''_2(x) \geq 0 \); the second technology, \( c_2(x) \), corresponds to a flat fee to ship anywhere on the segment; and \( \bar{x} = 1 \).

This shape of the cost function has a natural interpretation in physical space. To reach the customers located beyond some point (for example, out-of-city), the firm will find it better to use a flat fee courier service (e.g. Federal Express) than incurring the rapidly increasing shipping costs associated with its own shipping method.

If the shipping cost associated with the firm’s own technology does not rise as
rapidly as customers are located further away, then price discrimination will be lower, while market power remains very high. Figure 3 illustrates the effect, with two cost technologies for “nearby” customers, $c_{11}(x)$ and $c_{12}(x)$, where the former is flatter than the latter over a longer output range.

![Figure 3. Market Power Remains High as Price Discrimination Becomes Smaller](image)

The decrease in shipping cost $c_i(x)$ from $c_{12}(x)$ to $c_{11}(x)$ for all $x$ does not change the monopolist’s pricing schedule (it is still the flat schedule $c_2(2-x)$). But as the shipping cost decreases, the monopolist’s mean mark-up increases. Moreover, as the cost function flattens out for a wider range, customers further away from the firm are able to enjoy the firm’s service at nearer the same rate as customers located nearby. Thus, the standard deviation in mark-ups also decreases. Since the mean markup increases and the variation in mark-ups decreases, price discrimination, as measured by the CV, decreases. In the limit, as price discrimination vanishes, market power remains very high.

Thus, depending on the shape of the cost function for the firm and for the rival competitive industry, a high degree of price discrimination may be associated with a high or low degree of market power. Similarly, a low degree of price discrimination may be associated with either a high or low degree of market power. Thus, theory alone cannot correlate the extent of market power with the extent of price discrimination. We now
investigate whether the extent of price discrimination is a good indicator of market power in the airline industry, and find that it is not.

III. EVIDENCE

In this section, we use data from the US airline industry in the year 2000 to explore the empirical relationship between price discrimination and market power. We use a sample of hub and spoke airport pairs that was analyzed in Carbonneau (2003). An airport was defined as a “hub airport” if the total number of passengers that used the airport exceeded one million, the dominant carrier at the airport had at least a 20 percent share of all passengers whose point of origin was the airport, and at least 15 percent of its passengers flying in or out of the airport were connecting passengers.

Nineteen airports in the sample qualified as hubs. Only one carrier is dominant at each of these hubs, but a carrier is sometimes dominant at more than one hub. The sample comprises a total of seven dominant carriers: American, Continental, Delta, Northwest, TWA, United, and US Airways. These are called the “hub carriers.” An airport that is not a hub airport but is connected to a hub airport by a direct nonstop or one-stop flight is called a “spoke airport.” We consider only hub-to-spoke airport pairs serviced by a hub carrier. Moreover, we consider only direct, nonstop flight routes. The sample consists of a total of 953 hub-to-spoke airport pairs, between which one of the seven dominant carriers flies direct from the hub to the spoke, and back from the spoke to the hub.

Fare and quantity data for the hub-to-spoke airport pairs are drawn from the US Department of Transportation’s 2000 “Origin and Destination” Survey, which is a ten percent random sample of all flights on domestic carriers in the US. For each pair of origin and destination airports, we know the number of passengers, their itineraries, the fares they paid, and the identity of the carriers to which they paid them.

Market power is difficult to measure, because measures of cost are notoriously difficult to obtain. However, Carbonneau (2003) has demonstrated that hub carriers exercise greater market power on routes from one of their hubs to a spoke than on routes from the spoke to the hub. He found that hub-to-spoke fares are $34, or 7 percent, higher than spoke-to-hub fares. This difference cannot be accounted for by differences in marginal cost or product differentiation because passengers flying from a hub to a spoke are usually flying on the same planes as passengers flying from the spoke to the hub. This
leaves only one explanation: market power is higher on the hub-to-spoke markets than on the spoke-to-hub markets. Thus, we divide the routes of hub carriers between hub-to-spoke airport pairs according to whether they originate at the hub or the spoke, and we measure price discrimination for each of these two groups.

Our measure of price discrimination is the coefficient of variation (CV). We use the empirical analogue of the CV in equation (6):

$$ CV = \sqrt{\frac{\sum_{i=1}^{n} \left( \frac{(p_i - k)q_i}{Q} \right)^2}{\left( \frac{\sum_{i=1}^{n} (p_i - k)q_i}{Q} \right)^2}} - 1 $$  \hspace{1cm} (10)

where $p_i$ is the fare, $q_i$ is the quantity sold, $n$ is the number of routes, $Q$ is the total quantity sold, and $k$ is a constant, unobservable marginal cost, which is parameterized by the distance between the city of origin and that of destination. Setting $q_i = 1$, we have the exact discrete analogue of the expression in equation 6, except that the marginal cost is constant (because it is not observable).

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Frequency</th>
<th>CV$_{Hub\rightarrow Spoke}$</th>
<th>CV$_{Spoke\rightarrow Hub}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Airlines (AA)</td>
<td>118</td>
<td>0.564 (0.203)</td>
<td>0.552 (0.208)</td>
</tr>
<tr>
<td>Continental (CO)</td>
<td>177</td>
<td>0.555 (0.205)</td>
<td>0.576 (0.207)</td>
</tr>
<tr>
<td>Delta (DL)</td>
<td>203</td>
<td>0.567 (0.183)</td>
<td>0.573 (0.175)</td>
</tr>
<tr>
<td>Northwest (NW)</td>
<td>162</td>
<td>0.526 (0.162)</td>
<td>0.546 (0.177)</td>
</tr>
<tr>
<td>TWA (TW)</td>
<td>51</td>
<td>0.656 (0.195)</td>
<td>0.678 (0.206)</td>
</tr>
<tr>
<td>United (UA)</td>
<td>108</td>
<td>0.555 (0.177)</td>
<td>0.568 (0.175)</td>
</tr>
<tr>
<td>US Airways (US)</td>
<td>163</td>
<td>0.536 (0.180)</td>
<td>0.548 (0.171)</td>
</tr>
<tr>
<td>Total</td>
<td>982</td>
<td>0.556 (0.187)</td>
<td>0.567 (0.188)</td>
</tr>
</tbody>
</table>
Table 1 presents the CV means and standard deviations for the hub-to-spoke and spoke-to-hub routes of the hub-to-spoke city pairs serviced by different hub carriers. Surprisingly, the means of the CV on the spoke-to-hub routes are higher than those on the hub-to-spoke routes for six out of the seven dominant carriers. The t-statistics testing the hypothesis that the means of the CV are equal across the two directions are $t = -0.448$, $t = 0.959$, $t = 0.338$, $t = 1.061$, $t = 0.554$, $t = 0.542$, and $t = 0.617$, for American, Continental, Delta, Northwest, TWA, United, and US Airways, respectively, and $t = 1.299$ for the entire sample. At reasonable significance levels, we cannot reject the null hypothesis.

However, this analysis aggregates over markets with different cost structures. To overcome this problem, we note that a hub carrier’s marginal cost of flying from a hub to a spoke is approximately the same as that of flying from the spoke to the hub. Therefore, we can look at the difference between the CV for hub-to-spoke markets and the CV for spoke-to-hub markets. These differences in CV cannot be accounted for by differences in marginal cost. Table 2 presents the results of this differencing.

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Frequency</th>
<th># of Airport Pairs with $CV_{\text{Hub-Spoke}} &gt; CV_{\text{Spoke-Hub}}$</th>
<th># of Airport Pairs with $CV_{\text{Hub-Spoke}} &lt; CV_{\text{Spoke-Hub}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>118</td>
<td>61</td>
<td>57</td>
</tr>
<tr>
<td>CO</td>
<td>177</td>
<td>74</td>
<td>103</td>
</tr>
<tr>
<td>DL</td>
<td>203</td>
<td>91</td>
<td>112</td>
</tr>
<tr>
<td>NW</td>
<td>162</td>
<td>65</td>
<td>97</td>
</tr>
<tr>
<td>TW</td>
<td>51</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>UA</td>
<td>108</td>
<td>47</td>
<td>61</td>
</tr>
<tr>
<td>US</td>
<td>163</td>
<td>63</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>982</td>
<td>429</td>
<td>553</td>
</tr>
</tbody>
</table>

In formal terms, the sign of the expression $CV(\text{Hub-to-spoke}) - CV(\text{Spoke-to-hub})$ does not depend on $k$. 

Table 2. CVs on Hub-to-spoke v. Spoke-to-hub Routes

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4 In formal terms, the sign of the expression $CV(\text{Hub-to-spoke}) - CV(\text{Spoke-to-hub})$ does not depend on $k$. 

11
Consider the row for Northwest, for example. There are 162 spoke airports to which Northwest flies directly from its hub, and from which it flies directly back to its hub. Of these 162 airport pairs, 65 of them have a CV on the hub-to-spoke market that is greater than the CV on the spoke-to-hub market, while a greater 97 of them have a greater CV on the spoke-to-hub market. The p-value for such a binomial coming out 65 heads out of 162 trials is 0.0073, which is significant. In fact, five out of seven dominant carriers service significantly more airport pairs with a CV higher for the spoke-to-hub market.

However, differences between directional CVs need not be statistically significant. It could be that of Northwest’s 65 airport pairs that have a higher hub-to-spoke CV, most of them have a significantly higher (in a statistical sense) hub-to-spoke CV; while of Northwest’s 97 pairs that have a higher spoke-to-hub CV, most of them do not have a statistically higher spoke-to-hub CV.

To see whether this is the case, we test whether the differences in CVs in hub-to-spoke versus spoke-to-hub markets are statistically significant. To make inferences about calculated CVs, it is necessary to know something about their variance. We use two methods to compute their sampling variance, the delta method and bootstrapping. These methods are described in detail in a technical appendix available from the authors upon request.

Armed with estimates of the sampling variance of the hub-to-spoke and spoke-to-hub CVs, we test various null and alternative hypotheses concerning their differences. Table 3 reports the results of the various hypothesis tests with standard errors calculated using the delta method.

First, we test

\[ H_0^I : CV_{\text{Hub-Spoke}} - CV_{\text{Spoke-Hub}} \leq 0 \]
\[ H_A^I : CV_{\text{Hub-Spoke}} - CV_{\text{Spoke-Hub}} > 0 \]

The third column of Table 3 reports the number of airport pairs, for each dominant carrier, for which we reject the null-hypothesis \( H_0^I \) in favor of the alternative \( H_A^I \) (at the 1 percent significance level). In these airport pairs, the hub-to-spoke CV is significantly
higher than the spoke-to-hub CV.

Second, we test

\[ H_0^{II}: CV_{Hub-Spoke} - CV_{Spoke-Hub} \geq 0 \]
\[ H_A^{II}: CV_{Hub-Spoke} - CV_{Spoke-Hub} < 0 \]

The fourth column of Table 3 reports the number of airport pairs, for which we reject the null-hypothesis \( H_0^{II} \) in favor of the alternative \( H_A^{II} \). In these airport pairs, the hub-to-spoke CV is significantly higher than the spoke-to-hub CV.

The fifth column of Table 3 reports the number of airport pairs for which we neither reject \( H_0^{I} \) nor \( H_0^{II} \). In these airport-pairs, the hub-to-spoke CV is not significantly different from the spoke-to-hub CV.

The results indicate that five out of seven dominant carriers service significantly more airport pairs with a CV significantly higher for the spoke-to-hub market than airport pairs with a CV significantly higher for the hub-to-spoke market. For example, 61 of

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### Table 3. Significance Tests for Differences in CVs on Hub-to-spoke v. Spoke-to-hub Markets

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Freq.</th>
<th># of Airport Pairs with ( H_0^{I} : CV_{Hub-Spoke} \leq CV_{Spoke-Hub} ) Rejected</th>
<th># of Airport Pairs with ( H_0^{II} : CV_{Hub-Spoke} \geq CV_{Spoke-Hub} ) Rejected</th>
<th># of Airport Pairs with neither ( H_0^{I} ) nor ( H_0^{II} ) Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>118</td>
<td>59</td>
<td>53</td>
<td>6</td>
</tr>
<tr>
<td>CO</td>
<td>177</td>
<td>69</td>
<td>96</td>
<td>12</td>
</tr>
<tr>
<td>DL</td>
<td>203</td>
<td>86</td>
<td>106</td>
<td>11</td>
</tr>
<tr>
<td>NW</td>
<td>162</td>
<td>61</td>
<td>94</td>
<td>7</td>
</tr>
<tr>
<td>TW</td>
<td>51</td>
<td>26</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>UA</td>
<td>108</td>
<td>45</td>
<td>58</td>
<td>5</td>
</tr>
<tr>
<td>US</td>
<td>163</td>
<td>59</td>
<td>94</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>982</td>
<td>405</td>
<td>524</td>
<td>53</td>
</tr>
</tbody>
</table>
Northwest’s airport pairs have a significantly higher hub-to-spoke CV, while 94 of them have a significantly higher spoke-to-hub CV. In the total sample, only 405 airport pairs have a significantly higher hub-to-spoke CV, while a greater 524 of them have a significantly higher spoke-to-hub CV—even though market power is greater on the hub-to-spoke markets. Price discrimination and market power appear negatively correlated in our sample.

Table 4 reports the results of these tests using bootstrapped standard errors. The results are similar to those obtained using the delta method, except that there are fewer airport pairs for which we neither reject $H_0^I$ nor $H_0^{II}$.

Table 4. Significance Tests for Differences in CVs on Hub-to-spoke v. Spoke-to-hub Markets

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Freq.</th>
<th># of Airport Pairs with $H_0^I : CV_{Hub-Spoke} \leq CV_{Spoke-Hub}$ Rejected</th>
<th># of Airport Pairs with $H_0^{II} : CV_{Hub-Spoke} \geq CV_{Spoke-Hub}$ Rejected</th>
<th># of Airport Pairs with Neither $H_0^I$ nor $H_0^{II}$ Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>118</td>
<td>60</td>
<td>54</td>
<td>4</td>
</tr>
<tr>
<td>CO</td>
<td>177</td>
<td>74</td>
<td>101</td>
<td>2</td>
</tr>
<tr>
<td>DL</td>
<td>203</td>
<td>90</td>
<td>109</td>
<td>4</td>
</tr>
<tr>
<td>NW</td>
<td>162</td>
<td>65</td>
<td>96</td>
<td>1</td>
</tr>
<tr>
<td>TW</td>
<td>51</td>
<td>26</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>UA</td>
<td>108</td>
<td>46</td>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>US</td>
<td>163</td>
<td>62</td>
<td>99</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>982</td>
<td>423</td>
<td>542</td>
<td>17</td>
</tr>
</tbody>
</table>

These significant differences in CV between hub-to-spoke and spoke-to-hub markets cannot be accounted for by differences in marginal costs because these are the same in both directions. However, it is still possible that the differences in CV might also be partly driven by differences in demand. So we regressed the differences in CV on various measures of demand, employing different specifications. We found the effects of
these measures on CV-differences to be statistically insignificant. Differences in CV between hub-to-spoke and spoke-to-hub routes cannot be accounted for by population differences in the cities of origin or destination, or the number of business travelers on these routes. Having taken into account both potential cost and demand differences, we are led to the conclusion that price discrimination and market power are negatively correlated in the US airlines industry. This is consistent with the theory developed in the previous section.

IV. CONCLUSION

A static location model was employed to explore the relationship between price discrimination and market power. The model implied that a reduction in the differences in the costs of serving different customers would reduce market power while price discrimination, as measured by the coefficient of variation, could remain very high. Moreover, in the presence of a flat fee for very costly customers, a reduction of this kind could result in a substantial reduction in price discrimination while leaving market power unaffected, or even increasing it. The conclusion is that no generally positive relationship exists between the prevalence of price discrimination and that of market power, even in the short run.

Thus, the question of the relationship between the strength of price discrimination and that of market power becomes an essentially empirical one. Using data from the US airlines industry, we found that price discrimination and market power are negatively correlated, suggesting that, for this industry, the extent of price discrimination is not a good measure of the extent of market power.

Antitrust authorities have inferred high market power from highly discriminatory price structures. We have argued that there is no theoretical basis for this presumption; and, at least for the airlines industry, there is no empirical basis for it either.
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