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Measuring strategic firm interaction in product-quality choices: The case of airline flight frequency

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This paper investigates strategic interaction among airlines in product-quality choices. Using an instrumental variables approach, the paper estimates flight-frequency reaction functions, which relate an airline's frequency on a route to its own characteristics and to the frequencies of competing airlines. A positive reaction function slope is found in some cases, suggesting the presence of strategic interaction in the choice of frequencies. The paper also asks whether multimarket contact generates mutual forbearance in frequency competition, finding no evidence for such an effect.

1. Introduction

A voluminous theoretical literature deals with product differentiation and the choice of product quality. Horizontal product differentiation, where products have no natural quality ordering, is usually analyzed in a spatial-competition setting in the Hotelling tradition, with important contributions by d'Aspremont et al. (1979) and Salop (1979). Alternatively, Gabszewicz and Thisse (1979), Shaked and Sutton (1982) and other authors study vertical product differentiation, where products are ordered by quality and consumers have different quality valuations.

Despite the existence of this large theoretical literature, empirical work on product-quality competition is scarce. The purpose of this paper is to remedy this shortage by providing an empirical analysis of quality competition between firms, with a focus on the airline industry. The analysis studies what is probably the most important dimension of the quality of airline service: flight frequency. The importance of frequency was first shown empirically in the work of Morrison and Winston (1995), who use a multinomial logit model to analyze airline choices by passengers. In addition to finding that choices are influenced by fares and other elements of service quality, Morrison and Winston show that frequent daily departures by a given airline on a route strongly influence travelers to choose it. More recently, the structural demand estimates of Berry and Jia (2010) again show that flight frequency is highly valued by consumers.[1] Unlike existing empirical work on product-quality determination, which is structural in nature and is discussed below, the paper attempts to measure the strength of strategic interaction in quality choices by airlines. It does so by estimating flight-frequency reaction functions, which give a carrier's best frequency response to a competitor's frequency choice. The estimated reaction–function slope indicates the strength of any strategic interaction. However, the competitor's frequency, which appears on the right-hand side of the reaction function along with carrier and route characteristics, is an endogenous variable, being jointly determined along with the carrier's own frequency in a Nash equilibrium. Therefore, an instrumental variables approach is needed to generate a consistent estimate of the reaction function's slope.

Estimation of reaction functions is the focus of empirical work in a number of fields of economics. In public economics, the tax competition literature contains many studies that estimate reaction functions. Strategic interaction arises because tax rates in competing jurisdictions must be taken into account when a given jurisdiction chooses its own rate, recognizing that capital and labor migrate in response to tax-rate differentials. See Brueckner (2003) and Revelli (2005) for surveys of this literature, which relies on the methods of spatial econometrics. In addition, reaction functions are sometimes estimated in the literature on peer effects, where an individual's choice of the level of some decision variable depends on peer choices. See Manski (1993) for the conceptual framework and Dietz (2002) and Dujardin et al. (2009) for detailed surveys of the empirical peer-effects literature.

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[1] Prior to airline deregulation, when price competition was not allowed, airlines were viewed as competing excessively in flight frequency. Although deregulation enabled airlines to compete more vigorously in fares, airlines appear to still compete in flight frequency, and frequency has indeed increased since the hub-and-spoke system expanded airline networks (see Morrison and Winston, 1995).

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In both types of studies, the endogeneity of the peer's or the competing jurisdiction's choice must be taken into account in the estimation.

Estimation of reaction functions is, by contrast, somewhat less common in the industrial organization literature. Grabowski and Baxter (1973) and Cockburn and Henderson (1994) estimate what are effectively reaction functions for competing R & D investments among pharmaceutical firms, without labeling them as such (the endogeneity of the competitor's investment level is also ignored). Pinkse et al. (2002) estimate price reaction functions for gasoline wholesalers using a nonparametric approach, while Kalnins (2003) and Henrickson (2012) estimate such functions (for fast-food restaurants and sports teams, respectively), using spatial-econometrics methods. Escobari and Lee (2012) estimate price reaction functions for the airline industry, viewing competing flights as those with close departure times. Reaction functions have also been estimated in some papers as part of a procedure for deriving conjectural variations, which give a rival firm's anticipated response when a firm changes its price or output (see Liang, 1989; Dhar et al., 2005). Many studies estimating price reaction functions are also found in the marketing literature, with contributions by Lazzarini et al. (2007) (who focus on the auto-insurance industry), Reimer (2004) (who studies the ready-to-eat cereal industry), Cotterill et al. (2000) (who analyze the market for private-label and branded grocery products) and Vickner and Davies (1999) (who study the spaghetti sauce industry).[2]

Although distinguished by its focus on reaction functions, the present paper is related to a number of recent empirical studies analyzing the choice of product quality using structural models. The early structural literature (Berry, 1994; Berry et al., 1995) treats product attributes as exogenous, but recent empirical models have portrayed firms as choosing product quality along with price. In the models of Crawford et al. (2011) and Fan (2011), firms choose the levels of continuous measures of product quality (for newspapers and cable television, respectively), while firms in Draganska et al. (2009) choose which product varieties to offer (the empirical work focuses on ice cream flavors). In each case, the empirical exercise yields estimates of taste and cost parameters, which are used in the latter two papers to simulate the effects of mergers on product quality or variety.[3] By contrast, the estimated reaction functions in this paper do not identify underlying utility and production parameters, which are intermixed in the slope coefficient.[4] Instead, the goal of the paper is to measure the strength of strategic interaction, with the slope of the airline reaction function of interest in itself, not the values of the underlying parameters. The slope estimate can be used, for example, to compute the effects on equilibrium route frequencies of a parallel shift in one competing carrier's reaction function. As seen in section 6, such a shift could come from relaxation of a carrier's “scope clause,” which allows greater use of small planes and hence higher frequencies.

To motivate the empirical analysis, the paper reviews the theoretical frequency-competition model of Brueckner and Flores-Fillol (2007). To avoid the complexity of the spatial-competition approach, which is used by Schipper et al. (2003, 2007) and Lindsey and Tomaszewska (1999) to study frequency competition, Brueckner and Flores-Fillol introduce assumptions implying that average flight frequency is what matters (along with the fare) in the choice between airlines, not the departure times of individual flights. Despite the resulting elimination of space, the model effectively involves horizontal competition in the Hotelling tradition, with exogenous brand loyalty to individual carriers providing a choice friction analogous to the spatial friction in the Hotelling model. In contrast to this approach, Borenstein and Netz (1999) carry out an empirical analysis whose focus is the departure times of individual flights rather than overall frequencies, and they rely on a spatial competition model to motivate the analysis.[5]

Data for the estimation of flight-frequency reaction functions are readily available from government sources, which tabulate monthly airline departures on each nonstop route. Cross-sectional US domestic route data from a single quarter in 2010 are used for the estimation. Variables that shift a carrier's reaction function include route characteristics (distance, endpoint populations and incomes, a leisure-destination endpoint) as well as carrier characteristics, as captured by dummy variables indicating airline identities. The hub status of the route endpoints for the airline is another such characteristic. As noted above, the endogeneity of the competitor's frequency requires the use of instruments in estimating the reaction function, and the theoretical structure helps in choosing appropriate variables. The chosen instruments are the vector of carrier dummy variables for the competing carrier, which shift that carrier's reaction function and thus help determine its own frequency. Many of the reaction–function studies cited above similarly use competitor-characteristics variables as instruments, and carrier-identity dummies represent the most comprehensive way of capturing such characteristics. These variables are used in two-stage least squares estimation of the reaction function, with attention focusing on the second-stage slope coefficient.

The estimation is carried out for nonstop duopoly routes. With only two carriers present, interaction is more straightforward on such routes than on oligopoly routes. A pooled regression is carried out first, where LCCs (low-cost carriers) are not distinguished from legacy carriers. Since the coefficient of the reaction function might depend on the nature of the competitor, the pooled duopoly regression is supplemented with regressions focusing on legacy–legacy, LCC–LCC, and legacy–LCC duopolies.

In an extension of the basic model, the paper also asks whether multimarket contact shifts the frequency reaction function. Evans and Kessides (1994), Zou et al. (2011) and others study the effect of multimarket contact on fares, finding that airlines show mutual forbearance by pricing less aggressively on routes where multimarket contact with the competitors is high (fearing retaliatory behavior on other jointly contested routes). The question is whether such behavior extends to frequencies.[6]

Several conclusions emerge from the empirical analysis. First, the slope of the reaction function is positive when the two duopoly carriers are of the same type. That is, frequencies are strategic complements in duopolies involving two legacy carriers or two LCCs, with the size of the slope coefficients (around 0.7) suggesting that strategic interaction is strong. Second, on duopoly routes where carriers are of different types, weak performance of the carrier-dummy instruments prevents definitive conclusions from being reached. Therefore, while the empirical analysis suggests the presence of strategic frequency interaction *within* carrier types, no conclusion can be drawn regarding interaction

[2] Most of these papers recognize the endogeneity issue in their estimation procedures.

[3] For earlier non-structural empirical work on product quality, see Mazzeo (2002) and Crawford and Shum (2007).

[4] This mixture of parameters can be seen in the reaction–function slope derived in the theoretical analysis below (Eq. (11)).

[5] Their goal is to identify market characteristics that lead to greater clustering of departure times for different carriers. Other empirical papers on flight frequencies include Pai (2010), who explores the determinants of frequencies and aircraft sizes using a reduced-form approach, and Bilotkach et al. (2010), who focus primarily on the relationship between the frequency choice and trip distance, providing a theoretical model and empirical evidence.

[6] In work more closely related to the present exercise, Bilotkach (2011) studies the relationship between flight frequencies and multimarket contact in a reduced-form model, while Prince and Simon (2009) explore the impact of multimarket contact on flight delays and cancellations.