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Working Paper

Competitive outcomes in product-differentiated oligopoly

CSIO Working Paper, No. 0007

Provided in Cooperation with:

Department of Economics - Center for the Study of Industrial Organization (CSIO), Northwestern University

Suggested Citation: Mazzeo, Michael J. (2000) : Competitive outcomes in product-differentiated oligopoly, CSIO Working Paper, No. 0007, Northwestern University, Center for the Study of Industrial Organization (CSIO), Evanston, IL

This Version is available at:

<https://hdl.handle.net/10419/38681>

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THE CENTER FOR THE STUDY
OF INDUSTRIAL ORGANIZATION
AT NORTHWESTERN UNIVERSITY

Working Paper #0007

Competitive Outcomes in
Product-Differentiated Oligopoly

By

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March, 2000

^{*} This paper is a revised version of essay 2 of my Stanford University Ph.D. thesis. I am grateful to Tim Bresnahan for all his advice and help throughout the project. In addition, I would like to thank Shane Greenstein, Tom Hubbard, Mark Israel, Roger Noll, Paul Oyer, Mike Pries, Peter Reiss, Frank Wolak and Gavin Wright for very helpful comments and suggestions. All errors are my own.

Abstract

This paper analyzes price and quantity outcomes of firms operating in differentiated product oligopoly markets. Unlike prior studies, the empirical framework developed explicitly accounts for market structure determination while analyzing the effects of concentration and differentiation on market outcomes. This method emphasizes the logical relationship among firms' product choice behavior, market structure and price competition. It also addresses the endogeneity problem inherent when comparing the price and quantity of firms across different market structures. I estimate the competitive effects using data from a cross-section of oligopoly motel markets located along U.S. interstate highways. The results indicate that firms receive substantial benefits by offering differentiated products. The presence of any market competitor drives down prices, but the effect is much smaller when the competitor is a different product type. Differentiation is optimal product choice behavior because the resulting competition among firms is less tough when their products are differentiated.

I. Introduction

Profits ultimately determine whether firms enter a market and what types of products they offer. These decisions depend critically on how much firms can expect to earn from each of their available options. In an oligopoly context, a firm's payoffs depend on the entry and product-type decisions of its competitors as well as its own choices. Price competition may be tougher if the market contains more operating firms. Firms may be able to soften the price competition found in less concentrated markets, however, by offering differentiated products. Given market demand, quantity will also vary depending on firms' relative locations in product space. This paper examines how market structure affects the nature of price and quantity competition among firms. Using data from a large cross-section of motel oligopolies, in which firms are differentiated based on the quality of services they offer, the empirical analysis measures the impact of concentration and differentiation on the toughness of price competition, quantity determination, and firm payoffs.

The empirical work extends a long line of research on the relationship between market structure and the profitability of firms. Such studies have primarily examined homogeneous product markets; by analyzing data from a product-differentiated industry, I can evaluate a more detailed set of competitive effects. Specifically, the analysis identifies the price effect of additional market competitors and measures how the effects differ based on the relative product space locations of the competing firms. The results demonstrate that competitors have a less harmful effect when products are differentiated. In the case of motels, duopoly prices are about five percent lower than the monopoly price when the two competitors offer similar quality lodging services. If the quality of the two firms is different, however, there is no price effect. By differentiating the competitors are able to maintain the monopoly price.

The paper also proposes an econometric methodology to address the endogeneity problem that has plagued prior empirical work on the relationship between outcomes and market structure. Firms anticipate the competitive effects of market structure when making their entry and product type decisions. The variables used to explain the observed price and quantity outcomes — the competitors in each market and their product types — derive from the related entry and product choice stage of the game. As a result, I need to account for the correlation between unobserved factors that affect the entry and product-type decisions of firms and any error in the price and quantity regressions. To correct for the potential bias caused by this correlation, a market structure determination model developed in prior work (Mazzeo, 1998) is employed as a selection equation in a two-step estimation procedure. The second step price and quantity regressions are modified to reflect the market structure selection. Unlike previous studies of competitive outcomes, this permits an integrated empirical analysis of the entire game, emphasizing the

logical relationship among firms' entry and product choice behavior, market structure and price competition.

Following this introduction, I provide some background for the analysis of the competition stage of the game among oligopolists. Section III presents the two-step estimation procedure developed to measure the effects of concentration and differentiation on outcomes. The empirical work uses this procedure to analyze the price and quantity outcomes of motel firms located along interstate highways; the data used are outlined in section IV. In section V, I present the estimation results. Evidence from the analysis of price and quantity outcomes help demonstrate why motel firms find differentiation a profitable product choice strategy. Section VI provides some concluding remarks.

II. Background

This paper analyzes the competition stage of the game among differentiated oligopolists — in which price and quantity are determined given firms' previously made entry and product-type decisions. This section begins with a review of the theoretical literature, focusing on the role of price and quantity competition within the context of market structure determination. This theory provides motivation for the price and quantity regressions I estimate. Next, I summarize the previous empirical work on the relationship between competitive outcomes and market structure. This discussion highlights both the additional insights regarding product differentiation that my results provide and the econometric difficulties that my two-step estimation procedure addresses. I conclude this section with a brief overview of the motel industry, focusing on why it is an appropriate setting for this analysis.

II.A. Theoretical Framework for Evaluating Competitive Outcomes

Since Hotelling (1929), a substantial literature has developed which uses game-theoretic models to predict equilibrium product-type configurations and market outcomes in differentiated product oligopolies.¹ These models propose that firms compete in prices and quantities once all the firms operating in the market have made entry and product space location decisions. Firms make these entry and product choices by anticipating how price and quantity competition will play out, and what their resulting payoffs will be, under each product space location alternative. Within the subsequent competition stage, firms then select price and quantity to maximize profits given the product types they (all) have chosen.

In markets characterized by vertical differentiation, product types can be summarized by a single-index measure of quality. All consumers obtain more utility from a higher quality product, but they differ in

¹ Shapiro (1989) provides a thorough review of this literature.

their willingness to pay for quality. These heterogeneous preferences can be represented by a taste parameter, Ψ . Suppose that firms sell to a group of consumers who can be characterized by a distribution of their taste parameters, say $f(\Psi)$ defined over the range $[\underline{\Psi}, \bar{\Psi}]$. Each consumer gains utility $U_i = \Psi_i s_j - p_j$ from purchasing product with quality s_j and price p_j and chooses the product that offers the highest utility.²

Aggregating the individual decisions of all the consumers yields the total quantity purchased from each firm. Therefore, each firm's quantity depends on consumer demand (the size and shape of the $f(\Psi)$ distribution may differ across markets), on the prices firms charge, and on the relative product space location of the competitors (which were fixed in the previous stage). Together with its costs, the firm's chosen price and its resulting quantity constitute the payoffs it maximizes in the competition stage of the game. To illustrate how firm payoffs are determined, consider two firms of differing quality, denoted by s_1 and s_2 , and charging prices p_1 and p_2 .

Given a set of prices and product types, the consumers with a low value of Ψ select the low quality product (s_1) and the high- Ψ consumers choose the high quality product (s_2). The market shares for the two firms are determined by the taste parameter of the consumer who is indifferent between the two products; this consumer has a Ψ such that $\Psi s_1 - p_1 = \Psi s_2 - p_2$. The demand for each good will be:

$$D_1 = \int_{\underline{\Psi}}^{\frac{p_2 - p_1}{s_2 - s_1}} f(\Psi) d\Psi \quad D_2 = \int_{\frac{p_2 - p_1}{s_2 - s_1}}^{\bar{\Psi}} f(\Psi) d\Psi$$

Consider price competition between two firms, whose quality choices were fixed in the investment stage — the distance in product space between the two firms is Δs . Each firm takes Δs as given and maximizes $p_j = (p_j - c_j)D_j$ with its choice of p_j . If we further assume that $f(\Psi)$ is uniform, the following equilibrium prices, quantities and payoffs emerge:³

$$p_1 = c_1 + \frac{\bar{\Psi} - 2\underline{\Psi}}{3} \Delta s \quad p_2 = c_2 + \frac{2\bar{\Psi} - \underline{\Psi}}{3} \Delta s$$

$$q_1 = (\bar{\Psi} - 2\underline{\Psi}) / 3 \quad q_2 = (2\bar{\Psi} - \underline{\Psi}) / 3$$

² We may also assume that consumers have a reservation level of utility; that is, depending on prices and product space locations it may be optimal for consumers not to make a purchase (if $U_i < 0$).

³ This treatment follows Tirole (1988), p. 296-297. The derivation works out neatly assuming a uniform distribution and quantities chosen from a range such that each consumer buys one of the two competing products. Relaxing these assumptions changes the sizes of the product space location effects on price, but not their signs.

$$P_1 = \frac{(\bar{\Psi} - 2\underline{\Psi})^2}{9} \Delta s \qquad P_2 = \frac{(2\bar{\Psi} - \underline{\Psi})^2}{9} \Delta s$$

Because products may be differentiated and consumers gain different utility levels from each product type, a firm can charge a price higher than its marginal cost in equilibrium without losing its entire market share. Some consumers may be inclined to sacrifice the utility associated with paying the higher price, if they have a strong preference for that product type. Note from the demand functions, however, that the number of consumers purchasing each product is directly related to the price difference between the two products. This basic tradeoff between price and market share underlies the profit maximizing choices of firms in the competition stage of the game.⁴ The distribution of consumer preferences over product types will influence the terms of this tradeoff. If $f(\Psi)$ is skewed in favor of a particular product type, fewer consumers would switch to an alternative product in response to a price increase. The resulting price elasticity for a firm offering the popular type may be smaller. In contrast, firms offering an unpopular product type may need to charge a substantially lower price in order to attract customers.⁵

The relative product space location of competitors also affects the relevant elasticities. In cases where the other firms are located nearby in product space, equilibrium prices are closer to marginal cost. In other words, there is a first order effect which drives down the price of similar competitors — price competition is tougher when products are not differentiated.⁶ As a result, equilibrium profits are also increasing in the extent of differentiation between the firms. Also note the asymmetric predictions of the vertical product differentiation model. The payoffs for both firms are increasing in the product space difference between them, but the high quality firm's margin and payoff are greater than the low quality firm's. This advantage to higher quality was noted in models by Prescott and Visscher (1977) and Shaked and Sutton (1982, 1983), and will be explored in the empirical analysis below.

The impact of competitors' product space locations on payoffs provides the link between the competition and the investment stages of the game. Firms choose product type optimally, anticipating how

⁴ It is critical to assume that firms cannot price discriminate based on consumers' willingness to pay for quality. This assumption is reasonable in the context of the highway motels studied here.

⁵ In the empirical analysis below, I attempt to control for the consumer preference distribution across markets. Unfortunately, effectively capturing this distribution is difficult in the context of the motel industry. This provides motivation for the careful treatment of the unobservables and, specifically, the selection model developed in this paper. I will return to this topic at length below.

⁶ When there are multiple firms operating, there may be a second order effect throughout the market as well. The now lower prices of the close-together firms puts competitive pressure (through the demand function) on the firms located elsewhere in product space. Even though their products are differentiated, such firms may be forced to lower their prices in order to maintain an adequate market share.

price and quantity competition will proceed given their product choice and what their payoffs will be under each product-type configuration. Product differentiation influences the toughness of competition, the optimal price and quantity decisions, and profits — these in turn determine firms' entry and product choice behavior. The empirical analysis in this paper measures the effect of market structure on the competition stage outcomes, while incorporating the relationship of entry and product choice to price and quantity competition. Econometrically, using the product space location of competitors to explain price and quantity requires accounting for the unobservables that affect both price/quantity and product choice. The next subsection highlights the literature's inability to address this problem and motivates my proposed solution, which follows.

II.B. Empirical Profits-Concentration Literature

The literature that examines the effects of market structure on the competitive outcomes of firms began with analyses relating profits and market concentration that were a fundamental part of the structure-conduct-performance paradigm in industrial organization. In early papers, regressions that reported a positive correlation were treated as support for the hypothesis that firms would earn higher profits if they faced fewer competitors. Two serious flaws, however, called this interpretation into question. First, accounting information, which was the only proxy available for firm profits, does not appropriately represent the true economic profits firms earn. In fact, operational differences across firms render interfirm comparison of economic profits nearly impossible. Using accounting profits was a necessary, but inadequate, substitute.

Another criticism was more serious: even if a positive correlation between economic profits and concentration could be established, the direction of causation would remain in doubt. Perhaps, as Demsetz (1974) suggested, firm heterogeneity might explain the measured relationship. If firms have different capabilities, some are apt to be more profitable (e.g., have lower costs) than others — these firms ought to outperform their less capable counterparts. If the number of firms possessing relatively superior capabilities is small, only a few will survive. In this scenario, a positive correlation between profits and market concentration occurs because the small number of highly profitable firms translates into a concentrated market, not because more concentration somehow allows firms to earn higher profits. This

argument casts fundamental doubt on non-structural methods for examining the relationship between profits and market structure.⁷

Nonetheless, some authors proceeded to make improvements on these early regressions. Weiss (1989) responded to the above criticisms with a compendium of studies that explored the relationship between market structure and prices, rather than profits. Weiss contended that price data are not subject to the kind of reporting idiosyncrasies that make accounting profits data inappropriate for interfirm comparison. Moreover, since prices are determined in the market they ought not reflect the technical superiority of operating firms, as profits might. Weiss's book summarized a collection of more than 100 empirical analyses — the typical study regressed price (controlling for variables related to market-level costs) on some measure of concentration for a collection of markets in a homogeneous product industry — and concluded: “our evidence that concentration is correlated with price is overwhelming.”

The price and market structure regressions, however, leave a further econometric difficulty unaddressed. Because of the relationship between the investment and competition stages of the game, underlying shocks (to demand, for example) will affect both market structure and the prices charged by firms. As a result, market concentration measures used to explain price may be correlated with unobservables in the price regression, causing bias in its estimated parameters. To date, remedies for this endogeneity problem have had limited success.⁸ The difficulty Borenstein (1989) had finding suitable instruments for his market structure variables suggests that an effective two-stage least squares estimation procedure may remain elusive.⁹ Reiss and Spiller (1989) employ a promising approach that embeds price and quantity determination, along with some assumptions about the nature of price competition, directly within a model of entry. This more structural empirical strategy captures the effect of market structure on both outcomes and entry at once. Applying their model, however, is limited by the difficulty of solving for all the equilibrium price and quantity strategies when several firms are operating. Still, it demonstrates the gains to be made from an integrated analysis of market structure determination and price competition among oligopolists.

⁷ In fact, similar versions of this argument in related areas ultimately placed running structure-conduct-performance regressions in disfavor. The literature turned to more structural approaches in response, first theoretical, now empirical (see Bresnahan, 1992).

⁸ Evans, Froeb and Werden (1995) also recognize this problem. They propose a solution appropriate for regressions using panel datasets. Another recent study of market structure on outcomes by Emmons and Prager (1997) acknowledges the sources and potential consequences of the endogeneity problem, but does not attempt to endogenize market structure in response.

⁹ Using the characteristics of competitors as instruments ignores the equilibrium aspects of market structure determination.

The estimation procedure proposed in the following section extends the empirical literature on the effects of market concentration in two important ways. First, I estimate a much richer set of competitive effects on price and quantity. As hypothesized in the previous subsection, the impact of additional competitors ought to vary with product type — even without collusion, prices above marginal cost can be maintained in markets where products are differentiated. Therefore, we might expect the measured effects of additional market participants to depend on their product type. I investigate this hypothesis by regressing the observed price and capacity of the motels in my dataset on dummy variables representing the number of competing firms in their markets and the product type of each.¹⁰

The second contribution is the method for estimating the effect of competitors on the price and quantity of firms, while accounting for shocks that affect both market structure and market outcomes. Unlike the approach of Reiss and Spiller, price and quantity are not estimated simultaneously with the entry and product choices of firms. Instead, I follow the general practice in this literature and regress outcomes on a measure of market concentration. I employ a two-step estimation procedure to address the endogeneity of market structure. First, an equilibrium empirical model that predicts the number and product types of competing firms in the market. This model acts as a selection-type equation — its parameter estimates are inserted into subsequent price and quantity regressions to explicitly correct for the endogeneity of the market structure variables. In this way, the framework (described in detail below) incorporates the connection between the two stages of the game directly into the estimation.

II.C. Motel Industry

The motel segment of the lodging industry aims to serve automobile travelers along highways, and represents nearly half of the estimated 48,000 hotel properties in the United States.¹¹ Motels began to prosper during the first half of this century: as Americans purchased automobiles in larger numbers, it became popular to criss-cross the country on vacations and to travel from town to town for business. The industry was buoyed further by the National System of Interstate and Defense Highways, a 42,500-mile network of freeways established in 1956 and constructed in the years since. Business establishments

¹⁰ Bresnahan and Reiss (1991) measured the incremental price effects of additional competitors, but in undifferentiated markets (retail tire dealers). Their results indicated the highest prices in markets of one or two firms, with lower prices in markets of three or more firms. Prices were even lower in unconcentrated (more than five firms) markets. The authors did not account for the endogeneity of the market structure regressors in their analysis. Room capacity is the best proxy for quantity information that can be obtained for motels. Section IV provides further details.

¹¹ These data are from Standard and Poor's (1998), which estimates 1997 industry revenue at about \$80 billion. The 48,000 properties represent over 3.7 million rooms.

providing services for travelers have flourished along interstate highways, even in remote areas where little demand for such services would otherwise exist.¹²

While all motels provide the same basic services, they differ in the level of quality associated with these services. Industry observers have traditionally applied a single-index representation of differentiation based on quality to establishments in the roadside motel class of properties.¹³ In fact, market segmentation has become standard strategy in the motel industry — firms attempt to create niches of market power by offering price/quality combinations that appeal to a particular subset of consumers. Travel organizations like the American Automobile Association (AAA) have established ratings systems to provide consumers with accurate information about the quality of motel services. Using AAA's rating for each motel, I have categorized the motels in my sample into two product types: low and high quality. Further details on the dataset are presented in section IV.

Though franchising and chain-affiliation are widespread in the motel industry, independent entrepreneurs still make decisions for each individual property. This is crucially important for the empirical work, which fundamentally assumes that each characteristic of an establishment represents the choice which maximizes profits for that establishment. The individual franchisees or independent motel proprietors represented in my dataset almost certainly behave in this manner. The assumption that decisions are made locally is particularly appropriate for smaller rural markets, where franchisees choose their quality by selecting a chain to represent and independent motels remain quite common.¹⁴

III. Estimating Competitive Outcomes with Endogenous Market Structure

The theoretical framework outlined in the previous section suggests what ought to be included to explain the competition-stage equilibrium price charged by firms. Along with some measure of marginal cost, the presence of competitors and their product types influence this price. Therefore, I propose the following estimating equation for motel prices:

¹² Belasco (1979) is an excellent history of the early motel industry in the U. S. Recent trends and the current state of the industry are chronicled by Jakle et al. (1996).

¹³ See, for example, Dahl (1993) and Rompf (1994). It might be argued that certain classes of hotels differentiate themselves by the types of services they offer. Hartman (1989) has applied hedonic techniques to study demand for luxury and specialty hotels using amenities such as free parking, business/meeting services, and airport shuttles.

¹⁴ The establishment-level optimization assumption would not be ideal if franchisors make decisions for multiple outlets and the maximized franchise profit were not equal to the sum of the maximized profits for each establishment. Although several chains do own and manage some of their franchise outlets themselves, it is well documented that the company-owned establishments are more often located in urban areas (Brickley and Dark, 1987, LaFontaine, 1992). Nearly 45 percent of the rural highway motels in my dataset are not affiliated with a chain or franchise.

$$p_i = Z_p \mathbf{g}_p + h(\mathbf{f}_p; \bar{N}) + \mathbf{e}_p$$

where p denotes the firm's price. The Z -variables in the equation represent firm and market characteristics that affect costs (and may be reflected in reported prices) and \mathbf{e}_p are the unobservables that affect the firm's price. For motels, Z_p includes market-level demographic characteristics representing the costs of providing motel services at the particular market in which they operate. Some firm-level variables, including brand dummies, are also put into Z_p to control for within product-type differences in quality and chain-specific regularities such as particular price reporting policies.¹⁵ Some Z -variables may affect the costs and prices of low and high quality motels differently; terms can be included to allow the effects of such regressors to vary by product type.

While clearly necessary, the Z -variables in the price regression are primarily intended to serve as controls. The more economically interesting parameters are contained in the $h(\mathbf{f}; \bar{N})$ function, where the vector \bar{N} indicates the product types of the competitors a firm faces in the market.¹⁶ The theory presented above suggests that more competition causes prices to be lower, but that this effect may be offset by product differentiation. The goal of the empirical exercise is to evaluate these hypotheses by isolating the incremental impact each additional competitor has on the price charged by motel firms and comparing how the competitive effects vary by product type. For this purpose, I use a linear form for $h(\mathbf{f}; \bar{N})$, with a dummy variable indicating the presence and product type of each additional competitor:

$$\begin{aligned} h(\mathbf{f}; \bar{N}) = & \mathbf{f}_1 * \text{presence of first same - type competitor} \\ & + \mathbf{f}_2 * \text{presence of additional same - type competitors} \\ & + \mathbf{f}_3 * \text{presence of first different - type competitor} \\ & + \mathbf{f}_4 * \text{presence of additional different - type competitors} \end{aligned}$$

The vector \bar{N} indicates which of the ϕ parameters need to be inserted for each firm, based on the other firms operating in the market and their product types.¹⁷ The estimated ϕ parameters represent the incremental effect of competitors on price by product type, and thus the impact of market structure.

¹⁵ For example, a dummy indicating that a motel belongs to a chain such as Motel 6, which rarely offers discounts to their published prices, ought to have a negative coefficient if most other chains have transactions prices that are lower than the prices they report.

¹⁶ Think of market structure as an ordered pair (L, H), where L is the number of low quality firms and H is the number of high quality firms operating. For each firm, \bar{N} represents the product types of competing firms (not including itself). For a low-quality firm in market (L, H), $\bar{N} = (L-1, H)$; for a high-quality firm, $\bar{N} = (L, H-1)$.

¹⁷ For example, for the low quality motels operating in a (2,1) market, the dummy variables associated with the parameters ϕ_1 and ϕ_3 are "turned on" — for each there is one same-type competitor (low) and one different-type

Before estimating this price equation, it is necessary to confront the potential endogeneity of the market structure dummy variables contained in the $h(\mathbf{f}; \bar{N})$ portion of these firm-level regressions. Firms decide on entry and product choice by anticipating how price competition will proceed. The toughness of price competition, in part, determines the relative profitability of the alternative investment stage options of firms. Thus, just as market structure affects price competition, price competition helps determine market structure.

To illustrate, profits for the low and high quality product-type alternatives can be parameterized as:

$$\mathbf{p}_L = X\mathbf{b}_L + g(\mathbf{q}_L; \bar{N}) + \mathbf{e}_L$$

$$\mathbf{p}_H = X\mathbf{b}_H + g(\mathbf{q}_H; \bar{N}) + \mathbf{e}_H$$

The X variables in these equations are characteristics that affect profitability of (low and high quality) firms at the market. The $g(\mathbf{f}; \bar{N})$ function represents the effects of competing firms of each product type on profits. Theory suggests that additional competitors will reduce profits, particularly if the competitors are of the same product type. As a result, $g(\mathbf{f}; \bar{N})$ should contribute negatively when there are more competing firms. The error term is product type-specific, representing unobserved factors associated with the profitability of operating a motel of each product type at the market.

In the investment stage, each firm decides on its optimal action by comparing the profits of operating as each product type and not operating (normalized to zero). Given data for a market and values for the parameters, any set of draws for ε_L and ε_H translates directly into a prediction for the number of firms of each product type operating.¹⁸ Because the market structure outcome is essentially the same as the explanatory variables contained in the $h(\mathbf{f}; \bar{N})$ portion of the price regressions, the profit function errors need to be uncorrelated with unobserved characteristics that affect motel prices.

For example, consider the motels operating at a market with a (1,1) product-type configuration. Given a market's characteristics, the values of the profit function error terms that result in this market

competitor (high). For the high quality motel in this market, the relevant dummy variables multiply ε_3 and ε_4 (for the first and second different-type competitors). If the firm is the only one operating in the market, no dummies are turned on, while for motels in markets with three firms of each type (the largest considered) all the dummy variables take on a value of 1.

¹⁸ Mazzeo (1998) uses this framework to estimate an equilibrium model of entry and product choice based on these profit functions. The dependent variable of the model is the observed product-type configuration at a market, and the estimated parameters are used to calculate terms to correct for the endogeneity of market structure, as described below. Appendix A provides additional detail about the market structure model and the endogeneity correction procedure.

structure outcome can be denoted as $\{(\varepsilon_L, \varepsilon_H) : \tilde{N} = (1,1)\}$. Further, assume the price and profit errors are distributed as:

$$(\mathbf{e}_P, \mathbf{e}_L, \mathbf{e}_H) \sim \text{TVN with } \bar{\mathbf{m}} = [0 \ 0 \ 0] \text{ and } \bar{\Sigma} = \begin{bmatrix} 1 & \mathbf{r}_{L,P} & \mathbf{r}_{H,P} \\ \mathbf{r}_{L,P} & 1 & 0 \\ \mathbf{r}_{H,P} & 0 & 1 \end{bmatrix}$$

Critically, if we allow the potential of a nonzero correlation between $(\varepsilon_P, \varepsilon_L)$ or $(\varepsilon_P, \varepsilon_H)$ it is not valid to assume that $E[\mathbf{e}_P | (\mathbf{e}_L, \mathbf{e}_H) : \tilde{N} = (1,1)] = 0$.¹⁹ Because of the logical connection between prices and profits in the context of the multi-stage market structure game, both will be affected by underlying shocks to cost and demand. Thus, it is unlikely that the correlation between these error terms will equal zero. In fact, the expectation of the errors in the price and quantity equations ought to differ for each possible realization of a market's product-type configuration.

This troubling situation is analogous to the sample-selection problem often encountered in labor econometrics.²⁰ A two-step method can be applied to address the endogeneity problem in this context. The first step is a model that predicts the outcome on which the selection is based. Parameters from the selection model are then used to calculate correction terms that are inserted into the outcome regressions. These additional terms serve to subtract out the correlation between the price and profit errors. With the appropriate terms included, the error terms in the price regression now have mean zero. The second step simply runs the modified regression.

Performing this two-step estimation procedure requires an appropriate selection model — namely, one that predicts the market structure of product-differentiated oligopolies. Empirical market structure models have only recently been introduced in the industrial organization literature.²¹ In another paper (Mazzeo, 1998), I develop a model that uses the profit functions above to predict both the number and product types of competing firms in a market. Estimates from this model are used to calculate correction

¹⁹ Note that the price error is specified at the firm level, while the profit errors are type-specific. However, each firm (at a given market) draws the same ε_L for operating as a low quality motel and the same ε_H for operating as a high quality motel. If the price errors are also drawn from separate distributions for low (ε_{LP}) and high (ε_{HP}) firms, separate price/profit correlation terms can be specified: $\rho_{L,LP}$ and $\rho_{H,LP}$ for low-type prices and $\rho_{L,HP}$ and $\rho_{H,HP}$ for high-type prices. Analogous error and correlation terms may be defined for quantity as well.

²⁰ Heckman and MaCurdy (1986) discuss the problem and several empirical applications. Maddala (1983) also suggests a number of methods for estimating the parameters of this type of model.

²¹ Breshanan and Reiss (1991) and Berry (1992) began this line of research. Their models predict the number of competing firms in a market.

terms for the price regressions. Appendix A provides additional details about the entry and product choice model, and how the correction terms are calculated.

The resulting regression isolates the competitive (and other) effects on price from the unobserved factors that also influence the underlying profitability of these firms. An analogous procedure is used to correct for the endogeneity of the market structure variables in the quantity regression:

$$q_i = Z_q \mathbf{g}_q + h(\mathbf{f}_q; \bar{N}) + \mathbf{e}_q$$

As suggested by the demand functions derived earlier, Z_q includes regressors intended to capture the size and shape of the consumer demand distribution at each market. For motels, these include demographic variables associated with the number of travelers looking to stay at a motel in each location. The $h(\mathbf{f}_q; \bar{N})$ function contains the same dummy variables as in the price equation — measuring the incremental effects each competitor has on quantity, by product type. Finally, \mathbf{e}_q are the unobservables that affect the motel’s quantity; these may be substantial, as demand for transportation-related goods and services are difficult to model.

IV. Price and Quantity Data

This section describes the price and quantity data used to estimate the effects of market structure on competitive outcomes, following the procedure detailed above. The information is part of an extensive dataset collected from a cross-section of 492 differentiated-product oligopoly motel markets. These markets are all located at interstate highway exits outside Census-defined Metropolitan Statistical Areas (MSAs). Below, I outline the sources of these data and provide some summary statistics. I also discuss potential shortcomings in the price and quantity information collected and the effect these might have on the empirical results.

For this study, I define a market as the cluster of motels located adjacent to an individual interstate highway exit. We observe geographically isolated clusters of motels along most interstates; this practically limits the extent to which motels at one exit compete with motels at other exits.²² In an effort to avoid markets that are not oligopolies and to maintain a degree of homogeneity among the markets, I collected data from only small, rural exits. Each market in the dataset is located along one of the 30 longest U.S.

²² I do control for the physical distance between motel exits. Solomon (1994) and Bleakley (1995) provide interesting anecdotes regarding intermarket competition.

Interstate Highways.²³ Information must be obtained from every market participant in order to describe the equilibrium conditions in a given market accurately. I was able to assemble an exhaustive list of motel establishments at each market exit using Tourbooks published by the American Automobile Association (AAA), chain-affiliated motel directories, the American Hotel and Motel Association property guide, and telephone listings for each market.

A total of 1,817 firms were identified at the 492 markets. I assembled detailed information about each motel, including its chain affiliation, capacity (number of rooms) and price. I also assigned each motel in the dataset to a product type — either low or high quality. For properties listed by AAA, I used their quality rating of between one and four “diamonds” to make this assignment. Motels with a one-diamond rating were put into the low category, two diamonds and above in high. Chain-affiliated motels not listed by AAA were put into the category most populated by the members of the same chain that are in the Tourbooks. Because AAA has minimum quality standards for inclusion in its Tourbooks, independents AAA does not list were placed in the low quality category. Table 1 provides a breakdown of the motels in the dataset and their assigned quality levels. This quality level represents the product choice made by the firm; I examine competition among firms within and across these categories.

Next, I collected price information from the motel establishments. The sources used to identify market participants often reported a range of prices, rather than a unique transaction price. As the multi-stage game framework assumes, price decisions are less fixed than entry and product choice decisions for motels. In fact, some establishments adjust their prices quite often, charging different room rates for peak and off-peak seasons, on weekends and during the week, and even at various times of the day in extreme cases.²⁴ The lowest price in the range represents the base rate for a single customer, with higher prices listed for additional guests, larger rooms, and certain dates or periods (usually during the summer months or for special events). Where detailed information was available, it appears that the highest prices in the range remain in place for a much shorter period than the base price.²⁵ The high end of the range also exhibits much more volatility among the motels. Since the bottom end of the range most closely resembles

²³ Three-digit interstates and several one and two-digit interstates that do not cross a state boundary (e.g., 4 in Florida, 27 in Texas, and 97 in Maryland) or predominantly covered metropolitan areas (e.g., 84E, 91, and 93) were not included.

²⁴ McDowell (1995) reports how one motel uses intraday price variation as a yield management technique. This practice, however, is not common and has been denounced by industry trade organizations. I will consider the implications of period pricing when discussing the empirical results.

²⁵ For example, the Lake Country Inn in Clear Lake, Iowa charges a price during the “Buddy Holly Weekend” that is twice its normal room rate.

the actual prices paid by consumers across the properties in the dataset, I use the lowest published price for each motel in the analyses below.²⁶ For the properties surveyed by telephone, I requested the lowest one-person room rate for the motel.

Table 2.P summarizes the raw price data for the motels in the dataset. First, note the overall averages reported in the bottom row of the table. The average base price for low quality motels is \$28.02, while \$37.72 is the average for the high quality motels.²⁷ The rest of the table groups the motels based on the product-type configurations of the markets in which they operate. Each row in the table reports the base price averaged over all motels in the dataset in markets with the product-type configuration indicated in the first column — the low quality average in column two and the high quality average in column three. For example, the average base price of the low quality motels operating in markets with two low and two high quality motels is \$29.62; for high quality motels in (2,2) markets, \$39.18 is the average price.

The raw evidence regarding the hypothesized relationship between concentration, product differentiation and price is mixed. In markets with two firms, for example, price competition appears less tough when products are differentiated: both low and high quality motels charge a higher price (on average) when their competitor is a different quality level. The average price for a low quality motel in a (1,1) market is greater than in a (2,0) market (\$30.10 vs. \$28.56); likewise, the average price for a high quality motel in a (1,1) market is greater than in a (0,2) market (\$38.15 vs. \$35.65). This expected relationship also holds in markets with four and five motels, but breaks down in the three-motel markets. The regressions below analyze these hypotheses more carefully by adding market and firm-level controls for cost and quality differences and by using the procedure to correct for the endogeneity of market structure regressors described in the previous section.

Since motel rooms are typically rented on a per night basis, an accurate measure of quantity ought to record the number of rooms rented each night over a period of time. On any particular night, quantity may vary considerably depending on, among other things, the demand for accommodations on that night and the price charged. Obtaining per-night quantity data for all the motels in the dataset, however, was not possible. Instead, I have assembled the room capacity for each establishment. While capacity does not directly contribute revenue to the motel, it is certainly correlated (less some utilization ratio) with

²⁶ Although most properties maintain much higher prices for only a short period of time, these periods may provide a substantial portion of annual revenue. Since the empirical analysis focuses on relative prices in different competitive environments, it is more appropriate to compare the base prices motels charge across markets. The effect of peak-demand pricing periods on the empirical results will be explored in section 6.

²⁷ There is a cost associated with providing additional quality — the higher price for high quality motels does not necessarily indicate greater profitability.

quantity. The capacity data were quite straightforward to collect — I simply obtained the number of rooms available for rent at each establishment.

Table 2.K displays the average capacity for low and high quality motels operating in each product-type configuration in the dataset. Note that low quality motels are, on average, much smaller than high quality motels: the average low quality motel has about 38 rooms, while the typical high quality motel has nearly 66. This table also indicates that, without controlling for demand across markets, per-motel capacity is larger in markets with more motels. The relationship between capacity and product differentiation, moreover, is unclear. The average capacity is sometimes higher for motels whose competitors are the same product type: for example, the average high quality motel has 65.43 rooms when the market structure is (0,2) but only 57.15 rooms when operating in a (1,1) product-type configuration. This pattern is not universal, however, especially for low quality motels. Perhaps even more so for capacity, using additional firm and market-level controls and incorporating the corrections for market structure endogeneity are necessary to decode the relationship between capacity and market structure.

Before proceeding, it is worth contemplating the use of capacity as a proxy for quantity a bit more closely. It is certainly typical for a number of motel rooms to go unrented each night. This only poses a problem if capacity utilization differs across motels based on their markets' product-type configurations. When interpreting the capacity regressions, I explicitly consider scenarios under which capacity utilization might vary across market structures and the potential impact on the results. Additionally, this framework assumes that capacity is not chosen in the investment stage, along with the entry and product-type decisions. In such a game, it might be possible for firms to use capacity strategically — early movers may have an incentive to overinvest in capacity in an effort to deter later potential entrants. Capacity would not be at all representative of quantity in this case. However, fixed costs of entry have traditionally been quite low in the motel industry and investments in motel capacity are not particularly sunk. This limits the ability of firms to use capacity as an entry; as a result, capacity and quantity are likely to be highly correlated.²⁸

To complete the dataset, I appended several demographic and geographic variables describing conditions at each market to the motel information. From Census, I know the population, per capita income, and other demographics for each market. The annual average daily traffic that passes each

²⁸ Capital requirements have not typically constrained entry into the motel business. Jakle et al. (1996) describes promotions by motel associations and developers offering low-cost setups to potential motel operators in the first half of this century. Franchise companies, who often help arrange initial financing for their franchisees, serve this role today. In addition, several properties surveyed by telephone had once operated as motel, but were subsequently converted to apartment buildings. Rooms were also “shut down” on a temporary or seasonal basis in some properties. This also limits the ability of firms to use capacity as an entry deterrent.

market's exit along the interstate, which is monitored by the Federal Highway Administration (FHWA), is also included. I consulted a battery of AAA maps to determine the distance from each market to its nearest motel competition along the highway, noting whether the adjacent markets are also in the dataset or the reason why they were not included. These variables are used to help explain differences in competitive outcomes across markets, as described below.

V. Empirical Analysis of Competitive Outcomes

This section presents and discusses the parameters, estimated using the procedure outlined in section III, that measure the impact of market structure on competitive outcomes. By estimating the effect of market structure on outcomes, we can compute and evaluate (as firms do) how price and capacity will differ for each potential product choice, depending on the number and product types of competitors. The measured effect of market structure on outcomes is then compared to various theoretical hypotheses about entry and product choice. The regressions reveal the sources of the benefits to differentiating by comparing observed competition stage outcomes (price, capacity, and payoffs) of motels operating in different product-type configurations.

Indeed, the estimates of the price and capacity regressions described in the first part of this section reinforce the theoretical product choice literature — the effects of additional competitors on these outcomes are particularly strong when the motels are the same quality level. I also divide the sample of motels by their product type and run the regressions separately for the high and low quality subsamples, to determine how competitive effects vary in different regions of the product space. This allows me to reconcile the product space isolation results in the context of a vertically differentiated market, in which the high quality product type has inherent competitive advantages. This section concludes with a more direct comparison of the two stages of the game. I explicitly examine some hypotheses about entry and product choice using predictions of payoffs under different product-type configurations that are calculated with the estimates from the price and capacity regressions.

V.A. Price and Capacity Regressions: Results and Interpretations

To begin, Table 3.P displays the results of the price regression run on all the motels in the dataset.²⁹ The right-hand side variables include firm and market-level controls, the “Effects of

²⁹ The unit of observation in these regressions is a single motel; however, observations are weighted to avoid overemphasizing motels from the least concentrated markets. Each motel receives a weight of one divided by the total number of motels in its market. The results are similar when prices are expressed in logarithmic terms.

Competitors” dummies, and the endogeneity correction terms. As discussed above, controlling for demand and cost conditions at each market is necessary to isolate the competitive effects of concentration and product differentiation on price and capacity. Several of the market-level Z-variables (described in Table 5) associated with market-level motel costs are significantly correlated with the prices motel firms charge. For example, land prices are a major part of the cost of opening a motel and agriculture is the primary alternative land use in these rural markets. As a result, costs may be higher where agricultural land is more valuable and where the share of land used for farming is lower (perhaps there is an additional competing land use). Labor and materials costs are likely higher in markets with larger populations, higher incomes or nearby metropolitan areas. Labor may be relatively scarce and more expensive at markets in the WEST region, which tend to be more remote, but more available in the SOUTH. In each case, regressors associated with higher costs have a positive and significant effect on motel prices. The SPACING regressor captures the price elasticity associated with nonmarket competitors — prices are higher if the nearest market is further away. Finally, several motel-specific dummy variables (not listed in the table) effectively capture some of the within quality-level price differences among firms.³⁰

The “Effects of Competitors” estimates provide considerable support for the hypothesis that firms offering similar products are tougher competitors. The effect of the first same-type competitor is negative and statistically significant — prices in markets where a single same-type competitor is present are \$1.61 lower than in monopoly markets. On the other hand, if the first competitor is not the same product type, there is virtually no effect on price. This result crystallizes the benefits of differentiation: when competing firms offer the same product, the price premium afforded a monopolist disappears much more quickly than if the competitors offer different product types.³¹ Softer price competition results in the competition stage if firms have chosen differentiated products in the investment stage.

The parameters representing the effects of additional competitors provide another interesting result. The incremental effect on price of the second firm of the same product type is negative, but its impact is much smaller than that of the first same-type competitor and not different from zero statistically. The presence of the second firm of the other type, however, does affect prices negatively — the parameter estimate for ADNL-DIFF is negative 88 cents and the coefficient is statistically significant at

³⁰ In general, chain affiliation is associated with higher prices. Some individual chain dummy variables (Motel 6, Best Western, Budget Host), however, are negative and significant. The chain dummies represent idiosyncratic policies or business practices of franchises that are reflected in (published) prices. Elsewhere, motels with an attached restaurant charge significantly higher prices. The difference in prices for motels listed in AAA and those found in the phone survey was not, all else equal, statistically significant.

³¹ The difference between the price effects of the first same and first different-type competitor is statistically significant at the one percent level.

the 10 percent level. This result suggests that the benefits of offering a differentiated product erode when there is within-type competition elsewhere in product space. As mentioned in section II.A, there appears to be a second order effect, whereby tough price competition within one product type puts competitive pressure on prices throughout the market. In this case, price competition becomes somewhat tough, even for motels located in an isolated region of product space.

Finally, the bottom panel of Table 3.P displays the estimated coefficients for the terms included to correct for the endogeneity of the market structure dummy variables. These parameters represent the correlation between the unobservables that affect prices and the error terms in the low and high-type profit functions underlying firms' entry and product-type decisions. For the regressions run using all the motels in the dataset, I have specified the correction terms separately to allow the correlations to differ for high and low quality motels. Reading from top to bottom in Table 3.P, CORRECT-L*HI represents the correlation between the low profit error and the price error for the high quality motels in the dataset ($\rho_{L,HP}$) and CORRECT-H*HI is the correlation for the high type profit error ($\rho_{H,HP}$). For the low quality motels, CORRECT-L*LO is the correlation between their price error and the low profit error ($\rho_{L,LP}$), while CORRECT-H*LO is the estimated $\rho_{H,LP}$. The table shows that, for the price regression, none of the estimated correlations is statistically significant. Differences in the expectation of the profit errors across product-type configurations has no independent impact on price, suggesting that there is little correlation between the unobservable parts of prices and profits in this case.

Next, Table 3.K presents the estimates from the motel capacity regression run on all the motels in the dataset. The top panel of the table indicates that market-level variables associated with demand for lodging have a statistically significant effect on the capacity of motel establishments. For example, at markets where population and freeway traffic are greater, per-motel capacity is higher, all else equal.³² I also include variables representing demand elasticities — capacity is higher when alternative markets are further away and lower when a neighboring market is within a metropolitan area. Finally, motel capacity varies by geographic region. Firm-specific dummy variables are also included in the regression to help explain per-motel capacity, but are not listed in Table 3.K.

The estimates in the second panel again represent the incremental effects of competing firms. Two aspects of these results are of particular note. First, across the board, the effect on motel capacity of additional competing firms at the market is negative. The demand controls essentially reverse the

³² Along with the TRAFFIC variable obtained from the FHWA, I include METMILE as a measure of the “urban” traffic along highways. For each highway, METMILE represents the sum of the populations of all the MSAs through which the road passes divided by the total mileage the highway covers.

relationship implied by the raw data in Table 2.K, in which capacities were higher for motels in markets with more firms. When demand is held constant, the equilibrium capacity of motels is smaller in markets with more competitors, which is the more expected result. Second, the competitors whose estimated impacts are larger and statistically significant in the capacity regression — the first different-type and additional same-type firms — were the same ones whose presence had little effect on price. Conversely, the effects of the first same-type and additional different-type motels on capacity are negligible, but were negative and significant for price. This result simply reflects a downward-sloping demand curve for motels in part, since capacity is higher when prices are lower and vice versa. The capacity estimates also suggest that even though price competition may not be tougher, every additional firm has some competitive impact. In cases where prices are not competed down, capacities are lower when there is another firm in the market.

The results in the bottom panel of Table 3.K demonstrate that the endogeneity correction terms are statistically significant in the motel capacity regression. Capacity is higher for motels operating in markets where the unobserved portion of profits is positive, for both low and high quality motels. In other words, unobservables associated with larger capacities are also associated with higher profits. These estimated correlations appear somewhat stronger for the high quality motels in the dataset.

I have divided the sample into high and low product-type subsamples and separately estimated the price and capacity regressions for each subsample to determine how the effects of competitors and the control variables vary for motels of each product type. As outlined in section II.A, the vertical product differentiation theory literature predicts an asymmetry in the market power benefits and the effects of competitors in the low and high quality regions of product space. This prediction can be evaluated by looking for distinctions between the impact of same versus different-type competitors across the type-specific regressions. Meanwhile, the competitive effects measured separately by product type should still imply the tendency of firms to differentiate their products in the investment stage.

Breaking down the price regression by product type reveals a striking contrast in the competitive effects for low and high quality motels that was obscured in the full sample regression. Table 4.P demonstrates the familiar effect for the high-type subsample: the coefficient on 1ST-SAME is negative and significantly different from zero, while the effect of 1ST-DIFF is negligible.³³ In contrast, the difference between these parameters is much smaller in the price regression run on the subsample of low quality motels, and the negative effect of the first same-type competitor is not statistically different from

³³ For the high product type subsample, the estimated coefficient on 1ST-SAME is again significantly larger than that of 1ST-DIFF ($p = 0.06$).

zero. These tables suggest that the tough within-type price competition demonstrated in Table 3.P is largely confined to the high quality category. Such a result is consistent with the asymmetry typically found in theoretical models of vertical product differentiation. The models by Prescott and Visscher (1978) and Shaked and Sutton (1982) demonstrate that firms covet the high quality product space location and choose it first, because exclusivity there is more valuable. Reflecting this, the regression results indicate that there is more to gain from being the only high quality motel in a market and thus more to lose from the presence of a within-type competitor.

The opposite phenomenon occurs for the ADNL-DIFF dummy variable — in the high quality subsample, there is no effect of the second low-type competitor; however, the second high-type competitor has a negative and significant effect on the price of low quality motels. As described above, within-type competition for high quality firms is tough; this in turn affects the low quality prices. The price reduction caused by the entry of the second high quality firm is sufficiently large that these become a more attractive option for consumers whose preference for motel quality is weaker. The low quality firm must now lower its price in order to avoid losing some of its clientele to the more reasonably priced high quality competitors. Vertical product differentiation theory also portends this finding. In Shaked and Sutton's (1983) model, price competition among multiple high quality firms drives their prices down enough that the low quality firms cannot operate profitably. This effect is certainly present in the price regression for low quality motels, though it does not appear dramatically enough to prevent their entry.

The disparity between competition for high and low quality motels uncovered by the type-specific price regressions formalizes the mechanics underlying the benefits of product space isolation. These price estimates show why each firm has a strong incentive to select a different product type than its competitors offer: if the competitor is a high quality motel, the firm seeks to avoid the tough price competition measured here by choosing to be a low quality motel. If the competitor is low quality, the market power associated with high quality induces the firm to differentiate its product.³⁴

The remaining parameters indicate how the effects of the Z-variables differ between the low and high quality price regressions. The estimated effects are all the same sign, but tend to be larger and more statistically significant when explaining high quality motel prices. Note that the overall explanatory power of the regression is much lower for low quality. One potential explanation for this is that low quality

³⁴ The type-specific price regressions would have certainly supported the differentiation result had they indicated tougher within-type competition for lows as well. In fact, for reasons I will describe below, the low-type regressions are more difficult to specify and within-type competition may be tougher than estimated. However, the discussion here demonstrates that tough competition within one of the product types is sufficient to reconcile the outcome regressions with the product choice hypothesis.

motels have more substitutes, which are difficult to identify and control for. Some travelers may choose to sleep at a campground or rest area when prices at low quality motels are too high for their taste. Firms should face increased price pressure if these substitutes are readily available nearby their markets. Finally, dividing the sample does not affect the importance of the endogeneity correction terms, which are not statistically significant in either the low or high quality regressions for price.

The subsample capacity regressions in Table 4.K also demonstrate that estimating the competitive effects for the entire dataset conceals differences between low and high quality firms. Recall that both 1ST-DIFF and ADNL-SAME were negative and significant in the full sample capacity regression. Here we find that the effect of ADNL-SAME comes from high quality motels only and 1ST-DIFF matters only for low quality motels. These results also help substantiate the stated product choice hypothesis. The negative coefficient on ADNL-DIFF for low quality motel prices suggested that differentiating (selecting low quality) may not provide much benefit when there are already two high quality competitors. However, the negative and significant effect of ADNL-SAME on high quality capacity demonstrates the incentive firms in this situation have to choose low quality. To the extent that quantity follows capacity, the third high quality motel would rent fewer rooms and thus earn lower profits, even if its prices did not fall.

Finally, the Z-variables in the subsample capacity regressions reveal some differences that can be attributed to variation in the distribution of consumers' preference for quality across markets. For example, we might expect urban travelers to prefer high quality. METMILE, the measure of how urban a freeway's traffic is, comes in positive and significant for high quality capacity only. Conversely, the presence of a neighboring urban market, MSANEIGH, lowers high quality capacity. Unfortunately, further distinctions are hard to isolate, as demand for transportation-related goods and services are notoriously difficult to model. In the case of motels, I know the TRAFFIC that passes by each exit, but not whether these motorists are local or long-distance travelers and if they are driving passenger cars or commercial vehicles. It would also be useful to know if the distribution of motorists along the highway is any different in the evening, when people begin to look for a place to spend the night.³⁵ While there may be substantial demand error remaining, it is difficult to speculate how this additional error is distributed or what specific biases the misspecification might cause.

³⁵ Park Inn of York, Nebraska hails itself as being an "excellent stop for the interstate traveler located 9 hours east of Denver and 9 hours west of Chicago." Indeed, a York, NE dummy is positive and significant in the capacity regression. Although probably important, extremely detailed information on travel behavior would be required to properly incorporate this sort of effect into the outcome regressions framework.

To summarize, regressions run on the price and capacity outcomes of the competition stage provide evidence that helps explain why motels choose to differentiate their products. Competition, measured either through lower prices or capacity, is tougher when firms have chosen a product similar to those offered by other firms in the market. These competitive effects are consistent with the hypothesis that differentiation is a more profitable strategy. When broken down by product type, the results also support theoretical predictions regarding the asymmetry of quality space locations in vertically product differentiated markets. In the following subsection, I make the comparison between the outcomes results and the entry and product choice decision much more explicit. I also explore how altering the assumption regarding how capacity and quantity are related across product-type configurations influences this comparison.

V.B. Interpreting Market Outcomes through Backward Induction

One of the fundamental principles guiding the multi-stage game framework for studying oligopoly markets is that firms anticipate how the competition stage will proceed when they make their decisions in the investment stage. Before deciding on entry and product type, firms are able to gauge what their payoffs will be under each of the product choice options available to them. Considering these projections, they make the entry and product type choice that will ultimately yield the highest payoff. I evaluate the validity of this critical “backward induction” assumption in this final subsection. Using the estimated parameters from the price and capacity regressions, proxies are constructed to represent the payoffs firms can expect to earn under various product-type configurations. The endogeneity correction procedure permits a more accurate calculation of hypothetical prices and capacities in market structures that were not realized. I explicitly consider the relationship between the two stages of the game, by examining whether expectations about optimal entry and product choice behavior are fulfilled in the outcomes predicted for the competition stage.

Estimates from the individual product-type regressions are used to calculate predicted values for low and high quality motel prices and capacities under various alternative product-type configurations. These calculations are made for a hypothetical market in which all the explanatory variables take on their mean value (the “mean market”). Suppose that the product-type configuration at the mean market is (1,2).³⁶ Payoffs for firms operating in this market structure ought to be higher than in alternatives in which one of the firms has made a different choice — for example, if one of the high firms had selected low quality instead. Note that there are two distinct places where the product-type configuration factors into

³⁶ It happens that (1,2) is the product-type configuration predicted for the dataset’s mean market (Mazzeo, 1998).

the predicted outcome calculation. First it determines which of the market structure dummy variables are turned on in the price and capacity regressions. The corresponding parameter estimates are added into the prediction. Second, the values of the endogeneity correction terms are different for each market structure, because the product-type configuration defines the appropriate probability to calculate for the profit function unobservables (see section III). Correction terms are computed for each alternative market structure and inserted to calculate predicted outcomes. The remaining explanatory variables take on their mean value in the dataset.

The top panel of Table 6 displays the mean market's predicted prices and capacities under various product-type configurations for low quality motels; the high quality motel predictions are in the bottom panel. Note that both the competitive parameters and the endogeneity correction terms affect the predictions. The estimated impact of the first low quality competitor on low-type motel prices is, for example, about 96 cents (see Table 4.P). With the correction terms incorporated, the competitive effects become more pronounced and differ slightly depending on the number of high quality motels operating. The model predicts a price of \$30.63 for the low quality motel in a (1,0) market and \$29.36 — \$1.27 less — when one low competitor is present, making the product-type configuration (2,0). The predicted effect of the first same-type competitor also exceeds the parameter estimate alone between the (1,1) and (2,1) markets (\$1.24) and between the (1,2) and (2,2) markets (\$1.22). This result again demonstrates the importance of correcting for market structure endogeneity when evaluating the effect of competitors.

The last column in Table 6 contains the product of the predicted price and capacity for motels in each product-type configuration. This figure can be thought of, roughly, as potential firm revenue (the maximum a firm could earn if it filled its entire motel with paying customers) or as firm payoffs, along with some capacity utilization factor and marginal costs subtracted out.³⁷ With assumptions about how capacity utilization and marginal costs differ for firms in various market structures, we can compare predicted revenues across product-type configurations and evaluate whether the second stage results agree with our hypotheses about entry and product choice behavior. Where these do not agree, I consider what potential changes in the capacity utilization assumption would reconcile the two sets of results.

To start, we can judge whether any firm operating in the mean market would want to deviate from the (1,2) equilibrium configuration by comparing the “Predicted P*K” column for market structures implied by each alternative product choice. The predicted maximum revenue for a low quality firm in the (1,2) configuration is 990.86 and would fall to 923.99 if an additional low quality firm were to enter, making

³⁷ I abstract, here, from the fact that firms may charge different prices on different days. Below I will consider the effects of relaxing this assumption as well.

the market structure (2,2). In the investment stage, we assume that firms do not enter if it would be unprofitable to do so; this is consistent with the prediction that potential revenue would fall for an additional low quality firm. There would be a similar drop if another high quality motel were to enter, from the predicted value when operating in the (1,2) equilibrium configuration of 2,379.39 to 2,284.57 when the market structure is (1,3). Because providing quality is costly, payoffs cannot be compared directly using predicted P^*K , and it is more difficult to infer whether any of the extant firms would want to change its product type. Nevertheless, the evidence in Table 6 is strongly suggestive. For high quality motels, operating in the configuration that results if the low quality firm were to switch its product type — (0,3) would be the new market structure — yields the lowest predicted P^*K for high quality motels of all the configurations listed. The figure for a low quality motel in a (2,1) configuration is among the lowest predicted values in the top panel of Table 6.

To further check for internal consistency between the two stages of the game, we can compare the price and capacity predictions with a series of basic assumptions about entry and product choice behavior. Considering entry alone, it is reasonable to assume that additional competitors (of either type) lower profits. The product differentiation literature suggests that a firm will have higher profits when, given the same total number of market competitors, there are fewer firms of its own product type. The implied relationships between firm payoffs in different market structures translate into the profit function inequalities listed in the left-hand column of the bottom two panels of Tables 7 (for high firms) and 8 (for low firms). The remainder of these tables analyzes how well the competition stage predictions conform to these inequalities.

In the top panel of these tables, the predicted maximum revenue appropriate for each product-type configuration has been copied from Table 6 into the second column. Using these figures, I evaluate each of the implied profit function inequalities — indicating if it holds with a check mark in the second column of the bottom two panels. The results are mixed: for high quality firms, four of the eleven entry assumptions and all five of the hypothesized differentiation relationships hold. For low quality motels, ten of the eleven entry assumptions but just one of the five hypothesized differentiation relationships are true under the gross predictions for the price and capacity outcomes.

By themselves, these results are somewhat troubling, but recall that the competition stage predictions are for potential maximum revenues and do not represent actual payoffs. As discussed above, capacity utilization differences might alter the relationship between profits and maximum revenue across product-type configurations. In the third column of the top panel, I propose a set of capacity utilization

factors which, when applied to the predicted maximum revenue figures from the second column, make all the appropriate inequalities true. For the high quality type, the adjustment factor is simple — each additional market competitor reduces the average capacity utilization rate by 10 percent. Since travel patterns vary over the year, motels may have higher demand on weekends or during the summer months. When there are more firms in the market (and price competition is tougher), firms need to capitalize on the higher demand periods to be profitable. Having a higher capacity allows them to fill more rooms during these periods, but overall capacity utilization is correspondingly lower. If firms can also command higher prices during peak demand seasons, an even lower capacity utilization is required to be viable. For the low quality firms, the adjustment factors needed to satisfy the relevant inequalities follow a more complex pattern. Average capacity utilization decreases with the number of low-type extant firms, but also varies according to the number of high quality competitors in the market. Low quality firms have an easier time exploiting the higher demand periods when there are no high quality competitors; the ability to attract overflow or charge higher prices at peak times declines when they have high quality competitors. In this case, utilization varies less over the year and capacity remains closer to actual quantity.

The results presented in Tables 6 through 8 demonstrate how the analysis of the market structure effects on price and capacity fits together with the entry and product choice behavior of firms. The multi-stage game framework assumes that firms look at potential payoffs to operating under alternative market structure scenarios when they make their entry and product type decisions. With reasonable adjustments for capacity utilization, the price and capacity regressions estimated in this paper imply an array of payoffs that explain why firms choose to differentiate their products in the investment stage. The necessity of these capacity utilization factors illustrates that a dataset including actual product quantities might yield even more compelling results regarding the competition stage. Nevertheless, this analysis demonstrates the compatibility between the two stages of the game, and the source of the benefit firms gain in the competition stage from differentiating their products in the investment stage.

VI. Conclusion

This paper proposes analyzing price competition, product differentiation, and the entry and product type decisions of firms in an integrated manner. The empirical work stresses the logical connection between these elements — how they operate simultaneously to determine market structure and outcomes in product differentiated oligopolies. While each has been studied in isolation in prior empirical work, the analyses in this paper acknowledge and incorporate the links between them to better understand the role product differentiation plays in both market conduct and structure.

In this paper, I focus on the competition stage, in which the price and quantity outcomes of competing firms are determined. Using my sample of motel oligopolies, I examine how price competition and quantity determination are affected by market concentration and product differentiation. The goal is to discover how competition stage outcomes lead to product differentiation being the preferred strategy in the investment stage of the game. To accomplish this, an empirical method is introduced which directly integrates the decisions made by firms in the entry and product choice stage into the empirical analysis of competitive outcomes — linking the price and capacity regressions with a model that predicts market structure. This also permits me to correct for the potential bias caused by the endogeneity of variables measuring competition, a problem which has plagued prior studies of the effect of market structure on competitive outcomes.

The estimation results reveal that firms receive substantial benefits by offering differentiated products. Price competition is less tough when products are differentiated: the presence of any market competitor drives down prices, but the effect is smaller when the competitor is a different product type. Controlling for market characteristics, motel capacity is also smaller when there are more firms operating in the market. Taken together, along with reasonable assumptions regarding motel capacity utilization, the effects of market structure on outcomes measured in this paper demonstrate why differentiation turns out to be optimal firm product choice behavior. Firms choose to be different from their competitors because when products are differentiated, the resulting competition is less tough and payoffs are higher.

Table 1: Motel Chains Represented and Quality Category Assignments

Chain Affiliation	Number of Motels			Percent of Total
	Low Quality	High Quality	Total	
Budget Host	20	17	37	2.0 %
Best Western	1	174	175	9.6 %
Comfort Inn	0	98	98	5.4 %
Days Inn	16	129	145	8.0 %
Econolodge	5	65	70	3.9 %
Hampton Inn	0	17	17	0.9 %
Holiday Inn	0	82	82	4.5 %
Holiday Inn Express	0	12	12	0.7 %
Howard Johnson	2	13	15	0.8 %
HoJo Inn	3	7	10	0.6 %
Motel 6	27	0	27	1.5 %
Quality Inn	0	16	16	0.9 %
Ramada Inn	0	25	25	1.4 %
Scottish Inn	12	2	14	0.8 %
Super 8	4	144	148	8.1 %
Travelodge	2	5	7	0.4 %
Other Chains	23	81	104	5.7%
Independents	658	157	815	44.9 %
Totals	773	1,044	1,817	
Percent of Total	42.5%	57.5%		

Note: Data from AAA, chain affiliated motel directories, and phone survey of motel properties. Quality assignments were made by the author based on AAA ratings and chain affiliation.

Table 2.P: Average Motel Price in Different Product-Type Configurations

Product-Type Configuration	Average Motel Price	
	Low Quality Motels	High Quality Motels
(1,0)	\$28.51	---
(0,1)	---	\$35.48
(2,0)	\$28.56	---
(1,1)	\$30.10	\$38.15
(0,2)	---	\$35.65
(3,0)	\$30.93	---
(2,1)	\$26.29	\$37.05
(1,2)	\$26.17	\$35.50
(0,3)	---	\$39.10
(3,1)	\$28.82	\$45.69
(2,2)	\$29.62	\$39.18
(1,3)	\$29.66	\$38.24
(3,2)	\$26.95	\$39.08
(2,3)	\$27.23	\$38.46
(3,3)	\$26.13	\$38.32
Overall Average	\$28.02	\$37.72

Note: The product-type configuration indicates the number of motels of each quality type operating at the market — for the ordered pair (L, H), L is the number of low quality and H is the number of high quality motels operating. The average motel price is calculated over the motels of the given quality type operating in a market with the corresponding product-type configuration. Each motel's price is the low end of the range of motel prices reported in the various sources.

Table 2.K: Average Motel Capacity in Different Product-Type Configurations

Product-Type Configuration	Average Motel Capacity	
	Low Quality Motels	High Quality Motels
(1,0)	30.15	---
(0,1)	---	48.88
(2,0)	32.60	---
(1,1)	31.56	57.15
(0,2)	---	65.43
(3,0)	32.62	---
(2,1)	25.86	61.00
(1,2)	33.76	62.23
(0,3)	---	74.03
(3,1)	33.17	93.00
(2,2)	43.76	64.32
(1,3)	53.00	73.58
(3,2)	35.54	72.60
(2,3)	48.47	75.36
(3,3)	46.01	73.64
Overall Average	37.92	65.91

Note: The product-type configuration indicates the number of motels of each quality type operating at the market — for the ordered pair (L, H), L is the number of low quality and H is the number of high quality motels operating. The average motel price is calculated over the motels of the given quality type operating in a market with the corresponding product-type configuration. Capacity is the number of rooms available for rent in each motel.

Table 3.P: Motel Price Regression — All Motels

Dependent Variable: Motel Price (\$) — Mean = \$33.10

Observations: 1,815

R-Squared: 0.5417

Independent Variables:

<u>Variable</u>	<u>Parameter Estimate</u>	<u>Standard Error</u>	<u>t-Statistic</u>	<u>Sample Mean</u>
Intercept	26.4398	1.4305	18.483	1.000
<u>Effects of Competitors</u>				
1ST-SAME	-1.6080	0.4988	-3.224	0.594
ADNL-SAME	-0.6885	0.5880	-1.171	0.340
1ST-DIFF	0.1421	0.5098	0.279	0.698
ADNL-DIFF	-0.8819	0.5396	-1.634	0.463
<u>Market-Level Z-Variables</u>				
PLACEPOP	1.18E-4	3.47E-5	3.397	6,387.71
PERCAPI	4.09E-4	1.18E-4	3.465	10,309.43
FARMSHR	-2.0407	0.5881	-3.470	0.588
AGVAL	8.09E-4	3.25E-4	2.486	896.66
WEST	1.8193	0.5075	3.585	0.196
SOUTH	-1.3531	0.3716	-3.642	0.444
MSANEIGH	0.8143	0.3038	2.680	0.476
SPACING	0.0122	0.0062	1.954	54.971
<u>Endogeneity Correction Terms</u>				
CORRECT-L*HI	0.2715	0.3861	0.703	-0.033
CORRECT-H*HI	0.2198	0.4679	0.470	0.134
CORRECT-L*LO	0.5716	0.5878	0.973	0.204
CORRECT-H*LO	-0.5714	0.3773	-1.515	-0.022

Note: Dummy variables for motels with high quality, five individual chain affiliations, an attached restaurant, and AAA listing are not included in this table. Remaining variable definitions can be found in Table 5. Observations have been weighted to avoid overemphasizing motels from the least concentrated markets. Each motel receives a weight of one divided by the total number of motels in its market. Each motel's price is the low end of the range of motel prices reported in the various sources.

Table 3.K: Motel Capacity Regression — All Motels

Dependent Variable: Motel Capacity (# of rooms) — Mean = 52.55

Observations: 1,815

R-Squared: 0.5320

Independent Variables:

<u>Variable</u>	<u>Parameter Estimate</u>	<u>Standard Error</u>	<u>t-Statistic</u>	<u>Sample Mean</u>
Intercept	37.2145	3.2899	11.312	1.000
<u>Effects of Competitors</u>				
1ST-SAME	-2.0848	2.1727	-0.960	0.594
ADNL-SAME	-6.3514	2.5397	-2.501	0.340
1ST-DIFF	-5.3992	2.1835	-2.473	0.698
ADNL-DIFF	-1.0800	2.2937	-0.471	0.463
<u>Market-Level Z-Variables</u>				
PLACEPOP	0.0024	3.72E-4	6.351	6,387.71
POPSQR	-4.25E-8	1.07E-8	-3.966	8.56E+7
TRAFFIC	6.42E-4	9.10E-5	7.055	16,414.21
METMILE	5.09E-4	1.41E-4	3.607	9,171.57
MSANEIGH	-1.9551	1.2820	-1.525	0.476
SPACING	0.1058	0.0277	3.825	54.97
NORTHEAST	15.4714	3.5437	4.366	0.030
MIDWEST	-4.0046	1.3862	-2.889	0.329
<u>Endogeneity Correction Terms</u>				
CORRECT-L*HI	4.9822	1.6683	2.986	-0.033
CORRECT-H*HI	4.9990	2.0770	2.407	0.134
CORRECT-L*LO	4.2918	2.5843	1.661	0.204

Note: Dummy variables for motels with high quality, five individual chain affiliations, and AAA listing are not included in this table. Remaining variable definitions can be found in Table 5. Observations have been weighted to avoid overemphasizing motels from the least concentrated markets. Each motel receives a weight of one divided by the total number of motels in its market. Capacity is the number of rooms available for rent in each motel.

CORRECT-H*LO	2.2612	1.5968	1.416	-0.0218
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Table 4.P: Motel Price Regression — Subsample Analysis

		HIGH QUALITY MOTELS				LOW QUALITY MOTELS			
		Observations: 1,043				Observations: 772			
		R-Squared: 0.4600				R-Squared: 0.2742			
Independent Variables:									
<u>Variable</u>	<u>Parameter Estimate</u>	<u>Standard Error</u>	<u>t-Statistic</u>	<u>Sample Mean</u>	<u>Parameter Estimate</u>	<u>Standard Error</u>	<u>t-Statistic</u>	<u>Sample Mean</u>	
Intercept	29.9248	2.0417	14.656	1.000	26.7034	2.1632	12.344	1.000	
<u>Effects of Competitors</u>									
1ST-SAME	-1.4439	0.6268	-2.304	0.641	-0.9570	1.3710	-0.698	0.525	
ADNL-SAME	-0.2513	0.7755	-0.324	0.395	0.0764	1.6711	0.046	0.280	
1ST-DIFF	0.2103	0.8275	0.254	0.668	0.1246	0.7945	0.157	0.731	
ADNL-DIFF	0.1240	0.8896	0.139	0.405	-2.5247	0.8363	-3.019	0.526	
<u>Market-Level Z-Variables</u>									
PLACEPOP	1.57E-4	4.86E-5	3.241	6,687.72	6.16E-5	5.53E-5	1.114	6,059.45	
PERCAPI	5.78E-4	1.58E-4	3.657	10,321.19	1.87E-4	1.72E-4	1.085	10,296.56	
FARMSHR	-2.8476	0.7947	-3.583	0.579	-2.1489	0.8484	-2.533	0.598	
AGVAL	7.62E-4	4.85E-4	1.572	918.60	0.0011	4.36E-4	2.507	872.66	
WEST	2.9160	0.7019	4.154	0.177	0.0700	1.0364	0.068	0.216	
SOUTH	-1.6394	0.4966	-3.302	0.471	-1.1344	0.5404	-2.099	0.416	
MSANEIGH	0.4557	0.4009	1.137	0.476	1.0470	0.4421	2.368	0.477	
SPACING	0.0088	0.0079	1.112	54.894	0.0083	0.0114	0.730	55.055	
<u>Endogeneity Correction Terms</u>									
CORRECT-L	-0.1558	0.6377	-0.244	-0.062	-0.3917	1.7228	-0.227	0.428	
CORRECT-H	-0.0155	0.5804	-0.027	0.257	0.1067	0.5406	0.197	-0.046	

Note: Dummy variables for motels with five individual chain affiliations, and attached restaurant, and a AAA listing are not included in this table. Remaining variable definitions can be found in Table 5. Observations have been weighted to avoid overemphasizing motels from the least concentrated markets. Here, each motel receives a weight of one divided by the total number of motels of its product type in its market. Each motel's price is the low end of the range of prices reported in the various sources.

Table 4.K: Motel Capacity Regression — Subsample Analysis

HIGH QUALITY MOTELS					LOW QUALITY MOTELS			
Dependent Variable: Capacity (# of Rooms) — Mean = 65.92					Dependent Variable: Capacity (# of Rooms) — Mean = 37.92			
Observations: 1,043					Observations: 772			
R-Squared: 0.5171					R-Squared: 0.3971			
Independent Variables:								
<u>Variable</u>	<u>Parameter Estimate</u>	<u>Standard Error</u>	<u>t-Statistic</u>	<u>Sample Mean</u>	<u>Parameter Estimate</u>	<u>Standard Error</u>	<u>t-Statistic</u>	<u>Sample Mean</u>
Intercept	31.0235	5.2406	5.920	1.000	39.5999	5.5865	7.089	1.000
<u>Effects of Competitors</u>								
1ST-SAME	-3.5024	3.1788	-1.102	0.641	-3.7141	4.3771	-0.849	0.543
ADNL-SAME	-9.8201	3.9521	-2.485	0.392	-5.2318	5.1967	-1.007	0.280
1ST-DIFF	-1.0114	3.4007	-0.297	0.668	-10.2533	3.2921	-3.115	0.731
ADNL-DIFF	2.2974	3.5261	0.652	0.261	-3.4728	3.7622	-0.923	0.526
<u>Market-Level Z-Variables</u>								
PLACEPOP	0.0026	6.01E-4	4.326	6,687.72	0.0029	5.26E-4	5.430	6,059.45
PERCAPI	-4.03E-8	1.61E-8	-2.499	8.98E+7	-6.48E-8	1.58E-8	-4.100	8.09E+7
FARMSHR	6.04E-4	1.23E-4	4.909	16,919.85	7.72E-4	1.61E-4	4.804	15,860.94
AGVAL	8.14E-4	1.83E-4	4.443	9,245.96	2.29E-4	2.18E-4	1.051	9,090.17
WEST	-3.1435	1.6803	-1.871	0.476	-0.8764	1.9483	-0.450	0.476
SOUTH	0.0824	0.0351	2.348	54.89	0.1453	0.0466	3.116	55.06
MSANEIGH	28.1877	4.5165	6.241	0.033	-1.2868	5.6505	-0.228	0.028
SPACING	-5.333	1.8610	-2.866	0.319	-2.8750	2.1885	-1.314	0.341
<u>Endogeneity Correction Terms</u>								
CORRECT-L	2.0337	2.5894	0.785	-0.062	4.0874	5.2355	0.781	0.428

Note: Dummy variables for motels with five individual chain affiliations, and a AAA listing are not included in this table. Remaining variable definitions can be found in Table 5. Observations have been weighted to avoid overemphasizing motels from the least concentrated markets. Here, each motel receives a weight of one divided by the total number of motels of its product type in its market. Capacity is the number of rooms available for rent in each motel.

	HIGH QUALITY MOTELS				LOW QUALITY MOTELS			
	Dependent Variable: Capacity (# of Rooms) — Mean = 65.92				Dependent Variable: Capacity (# of Rooms) — Mean = 37.92			
	Observations:		1,043		Observations:		772	
	R-Squared:		0.5171		R-Squared:		0.3971	
CORRECT-H	7.1511	3.1452	2.274	0.257	5.1357	2.2241	2.309	-0.046

Table 5: Explanatory Variables Used in the Outcome Regressions

Variable Name	Description
PLACEPOP	Population of motel market's nearest town
POPSQR	Square of PLACEPOP
PERCAPI	Per capita income of market county's residents
FARMSHR	Percentage of land in market county used for agriculture
AGVAL	Per acre value of agricultural land in market county
TRAFFIC	Annual Average Daily Traffic on Interstate at the market exit
METMILE	Population of metropolitan areas along highway divided by total highway mileage
MSANEIGH	Dummy variable; equals one for markets with an adjacent MSA
SPACING	Miles from market exit to closest motel markets along highway
WEST	Dummy variable; equals one for markets in the West region
SOUTH	Dummy variable; equals one for markets in the South region
MIDWEST	Dummy variable; equals one for markets in the Midwest region
NORTHEAST	Dummy variable; equals one for markets in the Northeast region
CORRECT-L	Value of the expectation of the low quality profit error, given the observed market structure.
CORRECT-H	Value of the expectation of the high quality profit error, given the observed market structure.

Note: In Table 3, the effect of the correction terms is specified separately for low and high quality motels.

Table 6: Predicted Price and Capacities for Low and High Quality Firms at the Mean Market

Product-Type Configuration	Predicted Price — Low	Predicted Capacity — Low	Predicted P*K — Low
(1,0)	30.63	39.45	1,208.21
(0,1)	---	---	---
(2,0)	29.36	39.33	1,154.78
(1,1)	30.82	34.57	1,065.60
(0,2)	---	---	---
(3,0)	29.08	37.81	1,099.47
(2,1)	29.58	33.86	1,001.75
(1,2)	28.35	34.95	990.86
(0,3)	---	---	---
(3,1)	29.30	32.31	946.74
(2,2)	27.13	34.06	923.99
(1,3)	28.45	40.66	1,156.59

Product-Type Configuration	Predicted Price — High	Predicted Capacity — High	Predicted P*K — High
(1,0)	---	---	---
(0,1)	39.21	58.64	2,299.36
(2,0)	---	---	---
(1,1)	39.25	61.31	2,406.18
(0,2)	37.74	61.89	2,335.34
(3,0)	---	---	---
(2,1)	39.26	65.10	2,555.75
(1,2)	37.79	62.96	2,379.39
(0,3)	37.46	59.87	2,242.44
(3,1)	39.12	66.92	2,618.93
(2,2)	37.80	66.68	2,520.51
(1,3)	37.51	60.91	2,284.57

Note: Predicted values are calculated using parameter estimates from Tables 4P and 4K. The Z-variables take on their mean value in the dataset, while the product-type configuration listed in the first column defines which “effects of competitors dummy variables are turned on and the expectations calculated for the endogeneity correction terms. Column 4 is the product of columns 2 and 3.

**Table 7: Analysis of Predicted Values: Model Assumptions and Hypotheses
High Quality Product Type**

High-Type Profits	Predicted Maximum Revenue	Capacity Utilization Adjustment Factor	Adjusted Maximum Revenue
$\pi_H(0,1)$	2,299.36	---	2,299.36
$\pi_H(1,1)$	2,406.18	$(0.9)^1 = 0.9$	2,165.56
$\pi_H(0,2)$	2,335.34	$(0.9)^1 = 0.9$	2,101.81
$\pi_H(2,1)$	2,555.75	$(0.9)^2 = 0.81$	2,070.16
$\pi_H(1,2)$	2,379.39	$(0.9)^2 = 0.81$	1,927.31
$\pi_H(0,3)$	2,242.44	$(0.9)^2 = 0.81$	1,816.38
$\pi_H(3,1)$	2,618.93	$(0.9)^3 = 0.73$	1,908.17
$\pi_H(2,2)$	2,520.51	$(0.9)^3 = 0.73$	1,839.97
$\pi_H(1,3)$	2,284.57	$(0.9)^3 = 0.73$	1,667.74

Assumed Profit Function Inequality	True for Predicted Maximum Revenue?	True for Adjusted Maximum Revenue?
$\pi_H(0,1) > \pi_H(0,2)$		✓
$\pi_H(0,1) > \pi_H(1,1)$		✓
$\pi_H(1,1) > \pi_H(1,2)$	✓	✓
$\pi_H(1,1) > \pi_H(2,1)$		✓
$\pi_H(0,2) > \pi_H(0,3)$	✓	✓
$\pi_H(0,2) > \pi_H(1,2)$		✓
$\pi_H(2,1) > \pi_H(2,2)$	✓	✓
$\pi_H(2,1) > \pi_H(3,1)$		✓
$\pi_H(1,2) > \pi_H(1,3)$	✓	✓
$\pi_H(1,2) > \pi_H(2,2)$		✓
$\pi_H(0,3) > \pi_H(1,3)$		✓

Hypothesized Profit Function Inequality	True for Predicted Maximum Revenue?	True for Adjusted Maximum Revenue?
$\pi_H(1,1) > \pi_H(0,2)$	✓	✓
$\pi_H(2,1) > \pi_H(1,2)$	✓	✓
$\pi_H(1,2) > \pi_H(0,3)$	✓	✓
$\pi_H(3,1) > \pi_H(2,2)$	✓	✓

Note: Column 2 of the top panel is from the last column of Table 6. The assumed and hypothesized profit function inequalities are derived from the theoretical arguments in Section III of the paper. The capacity utilization factors were selected to allow all the inequalities to hold. Column 4 of the top panel is the product of columns 2 and 3.

$\pi_H(2,2) > \pi_H(1,3)$	✓	✓
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**Table 8: Analysis of Predicted Values: Model Assumptions and Hypotheses
Low Quality Product Type**

High-Type Profits	Predicted Maximum Revenue	Capacity Utilization Adjustment Factor	Adjusted Maximum Revenue
$\pi_L(1,0)$	1,208.21	---	1,208.21
$\pi_L(2,0)$	1,154.78	0.9	1,039.30
$\pi_L(1,1)$	1,065.60	---	1,065.60
$\pi_L(3,0)$	1,099.47	0.8	879.58
$\pi_L(2,1)$	1,001.75	0.9	901.58
$\pi_L(1,2)$	990.86	---	990.86
$\pi_L(3,1)$	946.74	0.8	757.39
$\pi_L(2,2)$	923.99	0.9	831.59
$\pi_L(1,3)$	1,156.59	0.8	925.27

Assumed Profit Function Inequality	True for Predicted Maximum Revenue?	True for Adjusted Maximum Revenue?
$\pi_L(1,0) > \pi_L(2,0)$	✓	✓
$\pi_L(1,0) > \pi_L(1,1)$	✓	✓
$\pi_L(2,0) > \pi_L(3,0)$	✓	✓
$\pi_L(2,0) > \pi_L(2,1)$	✓	✓
$\pi_L(1,1) > \pi_L(2,1)$	✓	✓
$\pi_L(1,1) > \pi_L(1,2)$	✓	✓
$\pi_L(3,0) > \pi_L(3,1)$	✓	✓
$\pi_L(2,1) > \pi_L(3,1)$	✓	✓
$\pi_L(2,1) > \pi_L(2,2)$	✓	✓
$\pi_L(1,2) > \pi_L(2,2)$	✓	✓
$\pi_L(1,2) > \pi_L(1,3)$		✓

Hypothesized Profit Function Inequality	True for Predicted Maximum Revenue?	True for Adjusted Maximum Revenue?
$\pi_L(1,1) > \pi_L(2,0)$		✓
$\pi_L(1,2) > \pi_L(2,1)$		✓
$\pi_L(2,1) > \pi_L(3,0)$		✓
$\pi_L(1,3) > \pi_L(2,2)$	✓	✓

Note: Column 2 of the top panel is from the last column of Table 6. The assumed and hypothesized profit function inequalities are derived from the theoretical arguments in Section III of the paper. The capacity utilization factors were selected to allow all the inequalities to hold. Column 4 of the top panel is the product of columns 2 and 3.

$\pi_L(2,2) > \pi_L(3,1)$		✓
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Appendix A: Market Structure Determination Model and Endogeneity Correction Procedure

As explained in Section III, it is likely that the market structure explanatory variables in the price and capacity regressions are correlated with the unobservables in these equations. A two-step estimation procedure is developed to correct for potential bias caused by the endogeneity. The difficulty in this case is that the error term in the price equation is not mean zero; in fact, it depends on the competing firms in the market. If $\bar{N} = (1,1)$, for example,

$$E[\mathbf{e}_p | (\mathbf{e}_L, \mathbf{e}_H) : \bar{N} = (1,1)] = \mathbf{r}_{L,P} * \frac{\iint \mathbf{e}_L f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H}{\iint_{\bar{N}=(1,1)} f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H} + \mathbf{r}_{H,P} * \frac{\iint \mathbf{e}_H f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H}{\iint_{\bar{N}=(1,1)} f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H}$$

where $\iint_{\bar{N}=(1,1)} f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H$ represents the probability that $\{(\mathbf{e}_L, \mathbf{e}_H) : \bar{N} = (1,1)\}$ holds.

Following remedies to address the sample selection problem often encountered in the labor economics literature, the endogeneity correction procedure used here removes the correlation between the price and profit errors by calculating predicted values for the expectations. This requires the market structure determination model, described fully in Mazzeo (1998), which estimates the likelihood function:

$$L = \prod_{m=1}^{492} \text{Prob}[(L, H)_m^O]$$

where $(L, H)_m^O$ is the observed configuration of firms in market m . For example, if $(L, H)^O = (1,1)$ for market m , the contribution to the likelihood function for market m is $\text{Prob}[(1,1)]$.

The market structure outcome depends on relative values of the profit functions described in section III. The observed market structure indicates that no firm would want to operate as the alternative product type, or would want to enter given the number and types of the extant firms. One (of the several) profit function relationship that defines the (1,1) market structure, therefore, is

$$\mathbf{p}_L = X\mathbf{b}_L + g(\mathbf{q}_L; \bar{N} = (0,1)) + \mathbf{e}_L > \mathbf{p}_H = X\mathbf{b}_H + g(\mathbf{q}_H; \bar{N} = (0,1)) + \mathbf{e}_H$$

This inequality indicates that with one high quality competitor, profits to operating a low quality firm (in a (1,1) market) are greater than operating a high quality firm (in a (0,2) market). Every market structure outcome is associated with a particular series of these profit function inequalities. Given market

characteristics, there exists a set of values for (ϵ_L, ϵ_H) for which each market structure's set of inequalities holds — thus the two dimensional integrals above. The full set of profit function inequalities translates into the limits of integration for each market structure outcome, which include the parameters (of the profit functions) to be estimated.

The procedure for estimating the price regression in this paper uses the parameter estimates for the market structure determination model to calculate predicted values for the integrals in the expectation above. These are then added into the expression for prices:

$$p_i = Z_p \mathbf{g}_p + h(\mathbf{f}_p; \bar{N}) + \mathbf{r}_{L,P} * \frac{\iint_{\bar{N}=(1,1)} \mathbf{e}_L f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H}{\iint_{\bar{N}=(1,1)} f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H} + \mathbf{r}_{H,P} * \frac{\iint_{\bar{N}=(1,1)} \mathbf{e}_H f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H}{\iint_{\bar{N}=(1,1)} f(\mathbf{e}_L, \mathbf{e}_H) \partial \mathbf{e}_L \partial \mathbf{e}_H} + \mathbf{m}_p$$

where the covariances ($\rho_{L,P}$ and $\rho_{H,P}$) have become additional parameters to be estimated. The key to the correction procedure is that μ_p now has mean zero. As a result, estimates of the effects of competitors and market characteristics will be unbiased and will no longer include any effects of the market structure selection.

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