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To Price Discriminate or Not: Product Choice and the Selection Bias Problem

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Abstract. In this paper, we investigate a gasoline station's incentive to price-discriminate by selling full-service gasoline as well as self-service gasoline. Unlike previous research, we explicitly model a firm's incentive to price discriminate by choosing to be either single-product or multi-product as a function of market and station characteristics. This allows us to make two contributions to research in the area: First, we highlight the importance of accounting for self-selectivity considerations that can arise in an empirical analysis of price discrimination that is based on market data. Second, we are able to show how the product and pricing choices of firms depend upon the market characteristics.

Using cross-sectional survey data on prices, station and market characteristics for 198 gasoline stations in the Greater Saint Louis area, we estimate a switching regression model of station decisions. Specifically, we employ a binary probit framework that models a station's decision to price-discriminate through the choice of the station-type as a function of market and station characteristics. We then estimate conditional linear regressions with self-selectivity corrections for the station's choice of prices. We show that incorrect inferences about the incentive to price discriminate and about the differences in the prices charged between single-product and multi-product stations would result if the endogeneity in the choice of the station-type were ignored in the estimation. The empirical analysis shows that a larger income spread in the market implies a greater likelihood of the gasoline station being multi-product. In addition, we have support for the various within firm and across firm price differentials as predicted by the theory of price discrimination.

Key words. price discrimination, product strategy, selection bias, switching regression, retail gasoline markets

JEL Classification: C12, C13, C34, C81, D21, D42, L95

1. Introduction

Price discrimination has long been recognized as a strategy that firms can use to maximize profits in markets where consumer tastes are heterogeneous and when inter-consumer arbitrage is difficult. When consumer tastes differ in terms of their valuations for a good, a firm can increase profits by developing a pricing scheme that separates consumers with different valuations. In most cases, while a firm knows the distribution of consumer valuations in the market, it does not know the exact valuation of any specific consumer prior to the sale. In these cases, a firm can allocate consumers to different prices through a process of consumer self-selection. For example, a firm can offer a menu of different prices, appropriately bundled with other aspects of the product (such as product quality), and force consumers to self-select into the appropriate bundle. If differences in costs incurred to produce the various bundles in this menu are small compared to the differences in prices, then this menu-based offering is a price discrimination mechanism.[1]

Retail gasoline markets present a good context to test price discrimination since different gasoline stations in a market typically face similar costs of procuring gasoline. Therefore, any price differences that emerge across gasoline stations are likely to be for reasons unrelated to the cost of procuring gasoline. For example, gasoline stations may significantly differ from each other in terms of the demographic characteristics of their local markets, which present them with different incentives to price-discriminate. Demonstrating that the observed station configurations and the associated price differences across gasoline stations are consistent with such differences in market characteristics is a way of empirically testing the phenomenon.

Gasoline stations choose to be one of two different types: a two-product station that offers both self-service and full-service gasoline or a single-product station that offers only full-service or self-service gasoline. A two-product station, by charging different prices for full- and self-service gasoline, induces consumers with different valuations to self-select the product that is consistent with their preferences. In other words, a two-product station engages in price-discrimination. A single-product station, on the other hand, is unable to price discriminate. If the marginal costs of offering full- and self-service gasoline are similar, then the standard theory of monopoly price-discrimination (as in Mussa and Rosen, 1978) predicts that the full-service price in a two-product station must be higher, and the self-service price at the same station must be lower, compared respectively to the full- and self-service prices at single product stations.[2] In fact, an influential paper by Shepard (1991) demonstrates this to be the case using price data from the Greater Boston retail gasoline market.

Our paper examines an important aspect of price-discrimination that has been ignored in previous empirical research: We explicitly examine a firm's incentive to price-discriminate. In doing so we highlight the importance of accounting for self-selectivity considerations in any empirical analysis of price discrimination that is based on market data. Specifically, we model a gasoline station's decision to be

1 Specifically this is second-degree price discrimination wherein a firm needs to know only the distribution of consumer preferences for price discrimination.

2 A recent paper by Rochet and Stole (2002) shows that second degree price-discrimination in a market with differentiated duopolists also produces outcomes that are qualitatively similar to the monopoly results. This is also consistent with the analysis in Desai (2001).

single-product or multi-product as a function of the characteristics of the station's local market. We then model the prices chosen by the gasoline station for its product(s), conditional on the station's decision to be a single- or multi-product station. Shepard (1991) estimates pricing decisions of gasoline stations without endogenizing their decisions to price discriminate, i.e., their choice to be single-versus multi-product. Explicitly examining a gasoline station's decision to price discriminate allows us to understand how the product and pricing choices depend on the characteristics of the market. In particular, we show the manner in which income variation in a station's local market affects its incentive to price discriminate and its product and price choices. Moreover, we show that not accounting for the decision of the station to price discriminate can lead to incorrect inferences about differences in the prices charged between single-product and multi-product stations.[3]

The empirical strategy involves two steps. We first model a gasoline station's decision to be single-product or multi-product, as a function of market and station characteristics, using a binary probit framework. We then model the station's pricing decision, conditional on the choice of the station type, using a linear regression framework with self-selectivity corrections. The two-step estimation procedure is a switching regression that accounts for the fact that prices are incompletely observed in the data. For example, we do not observe multi-product prices at single-product stations, i.e., the (hypothetical) prices that a single-product station would have chosen for its full- and self-service gasoline if the station had decided to be a multi-product station. Similarly, we do not observe single-product prices that would have been charged at multi-product stations. If one does not recognize the effects of these missing counterfactuals in the data, the estimated price regressions will suffer from self-selectivity bias (Maddala, 1983).

The selectivity bias idea can be understood with the following illustrative example: Price-discrimination theory predicts that self-service gasoline must be less expensive at a multi-product station than at a single-product station all else being equal. This means that for a given set of market characteristics, the optimal self-service price must be lower under the multi-product scenario than under the single-product scenario. Consider an example as shown in Figure 1 which plots the price of self-service gasoline as a function of some market characteristic I (suppose this is some relevant income characteristic of the market) for both multi-product and single-product stations. Suppose one attempted to test the prediction of the theory using empirical data that a station's decision to price-discriminate is based on the market characteristic I. Assume that a station will choose to be multi-product if $I \geq I^*$, and choose to be single-product if $I < I^*$.

This means that observed multi-product self-service prices in the empirical data

3 Another example of empirical analyses of price discrimination is Narasimhan (1984) who examines the role of coupons as price discrimination devices. Nevo and Wolfram (2002) examine the role of coupons in manufacturer competition and price discrimination and also deal with the endogeneity of coupon availability across markets.

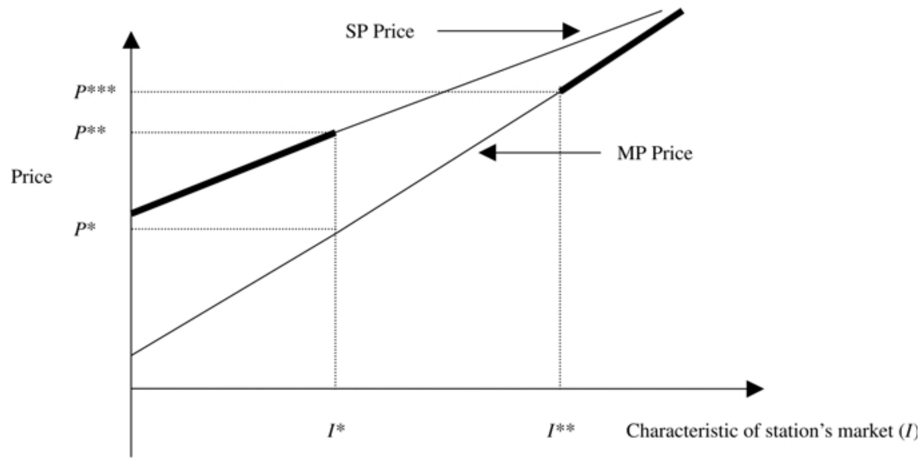

Figure 1. Price differentials between station types—an illustration of self-selectivity bias.

will be greater than P^* while observed single-product self-service prices in the empirical data will be lower than P^{**}. Suppose that the available data on multi-product self-service prices are, in fact, higher than some P^{***}, where $P^{***} > P^{**}$; as shown in Figure 1. Using this set of data, if one ignored the endogeneity of the station's decision to price-discriminate (i.e., ignored the influence of I), one would then conclude that single-product self-service prices (shown by the bold part of the SP Price line) are lower than multi-product self-service prices (shown by the bold part of the MP Price line), and therefore reject the hypothesis of price discrimination. This example shows that if endogeneity is not accounted for, it is possible to reach a conclusion that is directly opposite to what is truly represented in the data.

We present the theoretical predictions pertaining to price discrimination in retail gasoline markets and employ survey data from a cross-section of 198 gasoline stations in the Greater Saint Louis area, of which 60 are multi-product stations and 138 are single-product stations, to test these predictions. The data were collected during 1998 and include, for each gasoline station, the prices of three grades of gasoline along with station-specific characteristics (such as presence of convenience store, pay-at-pump etc.) and market characteristics. The empirical analysis demonstrates that there can be incorrect inferences made about station pricing behavior if the endogeneity in the choice of the station-type is ignored in the estimation. Consistent with the theory, the empirical analysis shows that a larger income spread in the local market implies a greater likelihood of the gasoline station being multi-product. In addition, we find that a larger income spread in the local market implies (1) a larger difference between full-service and self-service prices at a multi-product station, (2) a larger difference between multi-product full-service and single-product prices (with the former price always being larger than the latter), and (3) a larger difference between multi-product self-service and single-product prices (with the former price always being smaller than the latter).

We also investigate how the price discrimination decision depends on station characteristics. We find that a branded gasoline station is more likely than an unbranded station to be multi-product. The empirical analysis shows that ownership of a brand name leads to a larger price differential at a multi-product station, a larger difference between multi-product full-service and single-product prices, and a larger difference between multi-product self-service and single-product prices. We also find that gasoline stations with pay-at-pump facility or a convenience store are less likely to be multi-product stations, while gasoline stations with service stations are more likely to be multi-product stations.

2. Model and testable predictions

We present a simple model of price-discrimination and identify the empirically testable predictions. Market demand is modeled as in Mussa and Rosen (1978) and Moorthy (1984): the market consists of a unit mass of consumers and each consumer buys, at most, one unit of gasoline and has a utility function that is separable in income and consumption of gasoline. A gasoline station offers gasoline in two levels of service quality, i.e., full-service and self-service. Consumers are assumed to have a common reservation price for gasoline, but differ in their incomes and therefore their valuation of service quality.

Consumer surplus is formulated through a quasi-linear utility function $V = \theta s - p$, where p is the price of the product, and s is the level of service quality offered by the product. The parameter θ is a taste parameter that varies across consumers and represents the consumer's valuation for service quality. It is standard to interpret it as the inverse of the marginal utility for income and therefore differences in income can be seen as generating differences in the valuations for service. To see this suppose that consumers have preferences given by $U(I - p) + s$, where I is the consumer's income and thus $(I - p)$ is the consumer's net income. Note that preferences are separable in the net income and the service quality. Assuming that $U'(I) > 0$ and $U''(I) < 0$, and that the amount of money spent on gasoline is small compared to the total income $(p \ll I)$, we can approximate consumers' preferences by $U(I) - pU'(I) + s$. From this the surplus function that is relevant for the consumer's choice of this product is summarized by $\theta s - p$, where the parameter $\theta = 1/U'(I)$, the inverse marginal utility for income. Given our assumption of diminishing marginal utility for income (i.e., $U''(I) < 0$), we have that a higher value of θ corresponds to a higher consumer income level. We assume θ to be distributed according to the density function $f(\theta)$ defined on the interval $[a, b]$ and that this density function is uniform on $[a, b]$.

The firm/station makes the product-type decision (i.e., single-product versus multi-product), and then chooses gasoline prices conditional on the chosen product. The station chooses from two levels of service quality (denoted by $l = s, f$): full-service (s_f)and self-service (s_s). The variable cost per unit of providing service quality is convex and increasing, and (without loss of generality) represented by $c(s_l) = ks_l^2$.

The station chooses between being single-product (and offering only self-service or only full-service gasoline), and being multi-product (by offering both self-service and full-service gasoline). The decision to be multi-product involves an additional fixed cost F, for example, due to the opportunity cost of additional assets—such as additional land or pumping investments that need to be deployed.

Given the above, a single-product firm's maximization problem can be expressed as $\max_{(p_{SP},s)} \pi_{SP} = (p_{SP} - ks^2)\, q(p_{SP}, s)$, where $q(p_{SP}, s)$ is the demand function facing the firm. We will derive all testable predictions assuming that the firm serves all consumers in the market.[4] This requires that the consumer with the lowest valuation for service quality be served at the optimum. This means that the maximum price that can be charged is $p_{SP} = as$. The optimal choices for the single-product firm will be $p^*_{SP} = a^2/2k, s^*_{SP} = a/2k$. The optimal profits are given by

$$\pi^*_{SP} = \frac{a^2}{4k}. \tag{1}$$

The maximization problem facing a multi-product station is $\pi_{MP} = (p_f - ks_f^2)\, q_f(p_f, s_f) + (p_s - ks_s^2)\, q_s(p_s, s_s) - F$, subject to the individual rationality constraint of the consumer with the lowest willingness to pay, i.e., $as_s - p_s \geq 0$ and the relevant incentive compatibility constraint. The demands q_f and q_s are determined by the marginal consumer $\tilde{\theta}$ who is indifferent between full- and the self-service gasoline as identified by the incentive compatibility constraint $\tilde{\theta}s_f - p_f = \tilde{\theta}s_s - p_s$, which yields $\tilde{\theta} = p_f - p_s/(s_f - s_s)$. The optimal choices of the multi-product station can be derived to be $s_f^* = (a+b)/4k, s_s^* = (3a-b)/4k$ and $p_f^* = (2a^2 - ab + b^2)/4k, p_s^* = a(3a-b)/4k$. The optimal profits are given by

$$\pi^*_{MP} = \frac{1}{16(b-a)k}(b^3 + 7a^2b - 3ab^2 - 5a^3) - F. \tag{2}$$

We now draw the predictions of the model pertaining to product choice and price differentials that can be subjected to empirical testing.

2.1. *The choice of station type*

Consider the choice of a gasoline station to be single- or multi-product. The station chooses to be multi-product if $\Delta_\pi = (\pi^*_{MP} - \pi^*_{SP}) > 0$. Using equations (1) and (2), we can see that $\partial\Delta_\pi/\partial a < 0, \partial\Delta_\pi/\partial b > 0$. A station is more likely to be multi-product

4 The analysis of incomplete market coverage is available from the authors and does not change the testable predictions of the model. Full coverage of all consumers in this model implies that the spread in the income distribution be not too large.

in markets with lower a and higher b, all else being equal. For a given a, higher the difference between a and b (i.e., higher the spread in the income distribution of the market), greater the likelihood of a station being multi-product. In other words, for a given base level of income, the benefit of price discrimination is greater in markets with greater consumer heterogeneity in income. By offering two products the station is able to better span the spectrum of consumer preferences, and the benefit of doing so increases in the income spread of the market.

2.2. Between station price differentials

Recall that our focus on the incentive of gasoline stations to price discriminate means that we look at the station's choice of prices conditional on its choice of product-type. The differences between multi- and single-product prices are as follows:

$$\begin{aligned} \Delta_{(MP^f/SP)} &= (p^f_{MP} - p_{SP}) = \frac{b(b-a)}{4k} > 0, \\ \Delta_{(MP^s/SP)} &= (p^s_{MP} - p_{SP}) = \frac{a(a-b)}{4k} < 0. \end{aligned} \tag{3}$$

A multi-product station will charge a higher full-service price, and a lower self-service price, than a single-product station facing an identical market. When setting prices a multi-product station takes into account effects that are absent in the case of a single-product station. Suppose a multi-product station slightly raises its full-service price. While the station can earn greater profits on all its inframarginal full-service consumers who continue to buy its full-service product, it also faces a loss of demand for its full-service product from those consumers who stop buying it due to the higher price. But these consumers can switch to the station's self-service product. In contrast, for a single-product station, raising the price means loss of demand from the marginal consumers for the station. This sustains higher full-service prices at multi-product stations. Similarly, lowering the self-service price and offering lower quality allows the multi-product firm to sell to more consumers, while at the same time protecting its margins at the upper end of the market through the full-service product. The presence of the full-service product means that the multi-product station faces fewer inframarginal self-service consumers. Consequently, the self-service price at a multi-product station is lower than that at a single-product station.

The effect of income characteristics of the market on between station-type price differences is evident from (3) above. The greater the spread in income (i.e., greater the $b - a$), the higher the multi-product full-service price compared to the single-product price, and the lower the multi-product self- service price compared to the single-product price.

2.3. *Within station price differentials*

Using the equations for optimal prices for multi-product gasoline prices (preceding equation (2)) we have the result that for a multi-product station the difference between full- and self-service prices is larger in markets with greater income spreads. Because a single-product station does not price discriminate, its pricing strategy should be independent of the market spread in income.

3. Empirical methodology

We employ survey data, collected during July 1998, from a cross-section of 198 gasoline stations in the Greater Saint Louis metropolitan area.[5] Among the 198 stations, 60 are multi-product stations and 138 are single-product self-service stations.[6] The survey data include, for each gasoline station, the prices of three grades—87, 89 and 93 octane levels—of gasoline, along with station-specific characteristics, i.e., number of gasoline pumps, special advertising for cigarettes and soda, presence of convenience store, pay-at-pump facility, car wash, service station, oil/lube service, and acceptability of credit cards. Our dataset also contains demographic information—income, population, age distribution, home value, and education levels—pertaining to each gasoline station's market. This information comes from 1990 U.S. census data, which contain demographic information at the level of each census tract.

3.1. *Empirical measures*

The prices used in the analysis are the observed (posted) prices of gasoline in dollars per gallon. Since there are typically three grades of gasoline—87, 89 and 93 octane levels—sold in each gasoline station, we perform the empirical analysis separately for each grade of gasoline. A multi-product station contributes two prices—the full-service price P^f_{MP} and the self-service price P^s_{MP}—while a single-product station contributes one price P_{SP} to the empirical analysis.

5 The original sample included all the gas stations in the south and central Metropolitan area of Saint Louis. Our dataset originally consisted of a total of 246 stations. But 48 of these stations face immediate local competition from other stations, in the sense that they have at least one other station on the same side of the street whose posted price is visible. We excluded these stations from the analysis in order to make the data consistent with the theory discussed in Section 2 and also to focus the analysis on the endogenous choice of the product-type and its effect on market prices.

6 In addition, there were 13 single-product full-service stations. The low incidence of full-service single product stations is typical in the United States. Because they are few, we exclude them from the empirical analysis in the paper. However, the empirical results with these stations included in the analysis are given in the Appendix. As is evident from the Appendix, all the results of the paper remain unchanged.

In order to examine the effect of branding on price discrimination, we construct a dummy variable *BRAND* that takes the value 1 for national brands—Amoco, Shell and Mobil—and the value 0 for other brands. These three national brands invest significantly more on brand-building activities than unbranded gasoline stations and local brands such as Philips 66, Citgo, Quick Trip etc.[7] Other station characteristics are measured as follows: Dummy variable *PAY* takes the value 1 if the station has pay-at-pump facility and 0 otherwise, dummy variable *CONV* takes the value 1 if the station has a convenience store and 0 otherwise, dummy variable *WASH* takes the value 1 if the station has car wash facility and 0 otherwise, and dummy variable *SERV* takes the value 1 if the station has a service station and 0 otherwise.

We characterize the demographic characteristics of each station's local market using two measures: *AVG* measures the average income of the market, *SPREAD* measures the income spread of the market which is the standard deviation of the market's income distribution times two.

3.2. Econometric model

The analytical model of price discrimination involves two decisions. We empirically model the first decision (i.e., the station-type decision) using a binary probit model and the second decision (i.e., the conditional pricing decision) using a linear regression model with the self-selectivity correction. This two-stage model, also called a switching regression model, explicitly corrects for the self-selectivity bias that arises from prices being observed in the data only for each gasoline station's chosen station-type, and not for the non-chosen station-type. For example, we do not observe the price that a single-product self-service station would have chosen for its gasoline if it had decided to be a multi-product station instead.

Consider the problem of a gasoline station pricing self-service gasoline. The station's pricing decision can be described by two regression equations along with a criterion function that determines which of the two regression equations ("regimes") is applicable for the station. This is represented as follows

$$P = \mathbf{X}\beta_1 + u_1 \quad \text{iff } \mathbf{Z}\eta \geq u, \tag{4}$$

$$P = \mathbf{X}\beta_2 + u_2 \quad \text{iff } \mathbf{Z}\eta < u, \tag{5}$$

where P stands for the price of self-service gasoline at the station, $\mathbf{X}$ stands for a vector of station and market characteristics which influence gasoline pricing (and which will be specified in the Section 3.4), β_1 and β_2 stand for vectors of

7 Mobil spent $63 million on U.S. advertising in 1998, of which $40 million was directly spent on brand building activities, while Shell spent $56 million and Amoco spent $30 million in the same year (see Petrecca and Snyder, 1999, "Exxon Mobil taps DDB for Branding," *Advertising Age*, September, 1–2).

corresponding coefficients for regimes 1 and 2 respectively, u_1 and u_2 stand for unobserved variables that influence pricing in regimes 1 and 2 respectively, **Z** stands for a vector of station and market characteristics that influence the station's choice of station type, η stands for a vector of corresponding coefficients, and u stands for unobserved variables that influence the station's choice of station type. Whether or not the criterion function $(\mathbf{Z}\eta - u)$ is positive or negative determines which of the two regimes the station chooses. In general, u will be correlated with u_1 and u_2. For this reason, this econometric model is called "switching regression with endogenous switching" (see Trost, 1977 for an early application of this model to explain consumer demand for housing). Other econometric applications of this model have been in the context of explaining discrete/continuous choice decisions of households (Hanemann, 1984; Dubin and McFadden, 1984; Chiang and Lee, 1992; Chintagunta, 1993). The standard assumption is that u_1, u_2 and u follow a trivariate normal distribution with mean zero and covariance matrix Σ. The estimable parameters in this model are the parameters contained in the vectors $\boldsymbol{\eta}, \boldsymbol{\beta}_1, \boldsymbol{\beta}_2$ and the parameters contained in the matrix Σ. Empirical data on stations' choices of station type and relevant station and market characteristics contained in the vector **Z** can be used to estimate η. Data on stations' choices of prices and relevant station and market characteristics contained in the vector **X** can be used to estimate $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$ and Σ as explained in the next sub-section.

3.3. *Estimation*

In order to estimate the parameters of the switching regression model, we use the following two-step procedure.[8]

Step 1: We estimate a binary probit model of the gasoline station's decision of station-type, which is represented by the following choice probabilities:

$$Pr_{MP} = 1 - \Phi[-(\boldsymbol{\eta}_o + \mathbf{Z}_1\boldsymbol{\eta}_1 + \mathbf{Z}_2\boldsymbol{\eta}_2)], \quad (6)$$

$$Pr_{SP} = \Phi[-(\boldsymbol{\eta}_o + \mathbf{Z}_1\boldsymbol{\eta}_1 + \mathbf{Z}_2\boldsymbol{\eta}_2)], \quad (7)$$

where Pr_{MP} and Pr_{SP} stand for the probability of a gasoline station being multi-product and single-product respectively, Φ is the cdf of a standard normal distribution, $\mathbf{Z}_1$ is a vector of relevant market characteristics, $\boldsymbol{\eta}_1$ is the vector of corresponding coefficients, $\mathbf{Z}_2$ is a vector of relevant station characteristics, $\boldsymbol{\eta}_2$ is the vector of corresponding coefficients, and $\boldsymbol{\eta}_o$ is an intercept term.

8 Two-step approaches of this type were proposed by Heckman (1976) in order to facilitate the estimation of a wide class of censored regression models.

Step 2: We estimate a linear regression for prices that explicitly corrects for the effects of self-selectivity as shown below.

$$P = \beta_0 + \beta_{X1}\mathbf{X}_1 + \beta_{X2}\mathbf{X}_2 + \beta_{MP,s}\, I_{MP,s} + \beta_{MP,f}\, I_{MP,f} + \alpha_{MP,s}\, SS_{MP} I_{MP,s} + \alpha_{MP,f}\, SS_{MP}\, I_{MP,f} + \alpha_{SP}\, SS_{SP}\, I_{SP} + \varepsilon, \quad (8)$$

where β_o is the intercept parameter of the regression (which captures the baseline price of self-service gasoline at a single-product station), $\mathbf{X}_1$ is a vector of relevant market characteristics, $\mathbf{X}_2$ is a vector of relevant station characteristics, $I_{MP,s}$ is an indicator variable that takes the value 1 for multi-product self-service gasoline and 0 otherwise, $\beta_{MP,s}$ is the corresponding parameter (which captures by how much the price of self-service gasoline at a multi-product station differs from that at a single-product station), $I_{MP,f}$ is an indicator variable that takes the value 1 for multi-product full-service gasoline and 0 otherwise, $\beta_{MP,f}$ is the corresponding parameter (which captures by how much the price of full-service gasoline at a multi-product station differs from the price of self-service gasoline at a single-product station), and I_{SP} is an indicator variable that takes the value 1 for single-product self-service gasoline and 0 otherwise. The variable SS_{MP} is a self-selectivity correction variable for the multi-product regime, while the variable SS_{SP} is a self-selectivity correction variable for the single-product regime. Incorporating these variables corrects for the self-selectivity bias that would arise in the parameters of a pricing model that ignores endogenous regime switching. The self-selectivity correction terms are computed as follows (see Maddala, 1983).

$$SS_{MP} = \frac{\phi[-(\boldsymbol{\eta}_o + \mathbf{Z}_1\boldsymbol{\eta}_1 + \mathbf{Z}_2\boldsymbol{\eta}_2)]}{(1 - \Phi[-(\boldsymbol{\eta}_o + \mathbf{Z}_1\boldsymbol{\eta}_1 + \mathbf{Z}_2\boldsymbol{\eta}_2)])}, \quad (9)$$

$$SS_{SP} \frac{= \phi[-(\boldsymbol{\eta}_o + \mathbf{Z}_1\boldsymbol{\eta}_1 + \mathbf{Z}_2\boldsymbol{\eta}_2)]}{\Phi[-(\boldsymbol{\eta}_o + \mathbf{Z}_1\boldsymbol{\eta}_1 + \mathbf{Z}_2\boldsymbol{\eta}_2)],} \quad (10)$$

where, ϕ is the pdf of the standard normal distribution, and $\eta_1,\ \eta_2,\ \eta_3$ are estimated in the binary probit model of the gasoline station's station-type decision. In equation (8), $\alpha_{MP,s}$ and $\alpha_{MP,f}$ and α_{SP} are the coefficients of the self-selectivity variables for multi-product self-service, multi-product full-service and single-product self-service gasoline. Specifically, the parameter $\alpha_{MP,f}$ captures the covariance between the error terms associated with the multi-product decision and the full-service pricing decision, $\alpha_{MP,s}$ captures the covariance between the error terms associated with the multi-product decision and the self-service pricing decision, while α_{SP} captures the covariance between the error terms associated with the single-product decision and the self-service pricing decision (see Maddala, 1983).

3.4. Explanatory variables

Before estimating the proposed switching regression model using the estimation approach described above, we have to specify explanatory variables for the model. We include the following seven variables in Z in the binary probit model.

1. *AVG*, i.e., the average of the household income distribution of the station's local market,
2. *SPREAD*, i.e., the spread of the household income distribution of the station's local market,
3. *BRAND*, i.e., a dummy variable that takes the value 1 for a branded station and 0 otherwise,
4. *PAY*, i.e., a dummy variable that takes the value 1 if pay-at-pump facility is available at the station and 0 otherwise,
5. *CONV*, i.e., a dummy variable that takes the value 1 if a convenience store is available at the station and 0 otherwise,
6. *WASH*, i.e., a dummy variable that takes the value 1 if car-wash is available at the station and 0 otherwise,
7. *SERV*, i.e., a dummy variable that takes the value 1 if a service station is available at the station and 0 otherwise.

The first two variables are market characteristics (Z_1) that are necessary to test the theory. The remaining five variables are station characteristics (Z_2). We include *BRAND* to understand its effect on the incentive to price discriminate. A station's decisions pertaining to the configuration of its station characteristics—pay-at-pump, convenience store, car-wash and service station—involve costly investments that the station owner has made along with the station-type decision while setting up the retail facility. This justifies the inclusion of the variables *PAY*, *CONV*, *WASH* and *SERV* in the probit model. In the pricing regressions we include the variables *AVG* and *BRAND* in X. These variables are expected to affect the mean price level and we include them as controls. One would expect gasoline prices to be higher in markets with higher average income of the market and in branded gasoline stations.

4. Empirical results

We begin by presenting the main results pertaining to the effect of the income characteristics of the market on price discrimination incentives and on the observed prices. Next, we present the results on the consequences of ignoring endogeneity of the product decision to market characteristics. Finally, we discuss the results pertaining to the effect of branding and other station characteristics on the incentive to price discriminate.

Table 1. Binary probit results.

Parameter	Low grade (198 stations)	Medium grade (179 stations)	High grade (196 stations)
Intercept	**−1.74**	**−1.60**	**−1.72**
	(0.84)	(0.91)	(0.84)
AVG	0.02	0.02	0.02
	(0.02)	(0.02)	(0.02)
SPREAD	**0.01**	**0.01**	**0.01**
	(0.00)	(0.00)	(0.00)
BRAND	**1.31**	**1.44**	**1.30**
	(0.48)	(0.53)	(0.48)
PAY	**−1.30**	**−1.49**	**−1.30**
	(0.49)	(0.53)	(0.49)
CONV	**−0.73**	**−0.69**	**−0.73**
	(0.38)	(0.42)	(0.38)
WASH	− 0.04	0.01	− 0.03
	(0.37)	(0.41)	(0.37)
SERV	**2.31**	**2.44**	**2.30**
	(0.31)	(0.34)	(0.31)
Log-Likelihood	− 50.06	− 43.63	− 49.93

Significant estimates in bold, standard errors within parentheses.
Dependent variable: Whether or not a station is multi-product (1 = Yes, 0 = No). Number of observations: 198.

4.1. Product choice and prices

The product choice decision is modeled through the binary probit choice model. The estimates of this model is summarized in Table 1.[9] It is useful to note here that a gasoline station's decision to be single-product or multi-product depends on a comparison of the optimal profits in equations (1) and (2). As shown in Section 2.1, our model predicts that the higher the spread in the income distribution of the market, the likelier the firm is to be multi-product. This should manifest itself in the binary probit model as $\eta_{SPREAD} > 0$. In Table 1, since $\hat{\eta}_{SPREAD} > 0$ for all three grades of gasoline, the hypothesis pertaining to a gasoline station's decision of station-type is supported. Specifically, the higher the income spread of the market the more likely the firm is to be multi-product supporting the theoretical prediction.

We summarize the results of the pricing regressions in Table 2. The model is estimated separately for each grade of gasoline. Under columns labeled W (standing for "with self-selectivity correction") are reported the results of the proposed linear regression model with self-selectivity correction, as in equation (8). We simultaneously investigate the empirical consequences of ignoring the endogeneity of the gasoline station's station-type decision by also estimating the price regression in

9 While all the 198 stations in the data sold low-grade gasoline, 179 stations sold medium-grade gasoline and 196 sold high-grade gasoline.

Table 2. Results of pricing regression.

	Low grade		Medium grade		High grade	
Parameter	W	W/O	W	W/O	W	W/O
Intercept	− 2.49	− 0.94	− 2.70	− 1.04	− 2.23	− 0.83
	(1.90)	(2.52)	(2.03)	(2.78)	(1.88)	(2.54)
$I_{MP,s}$	**−2.77**	**5.76**	**−2.80**	**6.97**	**−2.81**	**5.71**
	(1.06)	(2.25)	(1.23)	(2.53)	(1.15)	(2.27)
$I_{MP,f}$	**0.62**	**11.08**	**0.75**	**12.74**	**0.74**	**11.11**
	(0.20)	(2.27)	(0.29)	(2.55)	(0.30)	(2.30)
BRA	**2.37**	**2.46**	**2.53**	**2.51**	**2.46**	**2.51**
	(1.00)	(1.29)	(1.02)	(1.45)	(1.05)	(1.30)
AVG	**0.10**	0.06	**0.10**	**0.06**	**0.10**	**0.06**
	(0.04)	(0.05)	(0.03)	(0.05)	(0.05)	(0.05)
$SS_{SP}\ I_{SP}$	**−1.15**	NA	**−1.19**	NA	**−1.15**	NA
	(0.29)	(NA)	(0.49)	(NA)	(1.24)	(NA)
$SS_{MP}\ I_{MP,s}$	**2.52**	NA	**2.46**	NA	**2.63**	NA
	(0.98)	(NA)	(1.38)	(NA)	(1.30)	(NA)
$SS_{MP}\ I_{MP,f}$	**20.40**	NA	**25.07**	NA	**21.26**	NA
	(1.32)	(NA)	(5.76)	(NA)	(5.38)	(NA)
PAY	NA	− 2.43	NA	− 2.26	NA	− 2.41
	(NA)	(1.65)	(NA)	(1.82)	(NA)	(1.66)
$CONV$	NA	0.03	NA	0.02	NA	0.08
	(NA)	(1.72)	(NA)	(1.90)	(NA)	(1.74)
$WASH$	NA	**4.92**	NA	**4.76**	NA	**5.00**
	(NA)	(1.72)	(NA)	(1.84)	(NA)	(1.74)
$SERV$	NA	**−8.18**	NA	**−9.63**	NA	**−8.15**
	(NA)	(2.07)	(NA)	(2.33)	(NA)	(2.08)
R-squared	0.12	0.19	0.14	0.20	0.12	0.18
Adjusted *R*-squared	0.09	0.16	0.11	0.17	0.09	0.16

Significant estimates in bold, standard errors within parentheses W, with self-selectivity correction; W/O, without self-selectivity correction. Dependent variable: Price of gasoline. Number of observations: 258.

equation (8) after ignoring the effects of self-selectivity, which yields the following estimable equation.

$$P = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_{MP,s} I_{MP,s} + \beta_{MP,f} I_{MP,f} + \varepsilon. \quad (11)$$

The results of this regression model are reported in Table 2 under columns labeled W/O (standing for "without self-selectivity correction").

Under the W regression, in order to obtain the correct asymptotic covariance matrix for the two-stage estimates, we apply the procedure suggested by Maddala (1983, p. 227). The reported standard errors in Table 2 are these corrected standard errors (see the Appendix of Chapter 8 of Maddala, 1983, for a detailed exposition of this correction procedure). The differences between the uncorrected and corrected standard errors are quite small in magnitude in general, which means that the results of significance testing for the individual coefficients in the table are identical between the uncorrected and the corrected linear regressions at the 95% significance level.

First we will discuss results pertaining to our proposed linear regression model, represented under the columns labeled P. Our theoretical model's predictions on the price differentials between and within price regimes (as discussed in Sections 2.2 and 2.3) are that $(P^f_{MP} - P_{SP}) > 0, (P^s_{MP} - P_{SP}) < 0$ and $(P^f_{MP} - P^s_{MP}) > 0$ for each gasoline station in the dataset. These three implications about price differentials should manifest themselves in the linear regression model as $\hat{\beta}_{MP,f} > 0$ and $\hat{\beta}_{MP,s} < 0$. As expected, for all three grades of gasoline, we find that $\hat{\beta}_{MP,f} > 0$ and $\hat{\beta}_{MP,s} < 0$, which lends empirical support to the implications of the theoretical model. We also find that that $\hat{\beta}_{AVG} > 0$, i.e., gasoline stations in richer neighborhoods charge higher prices than stations in poorer neighborhoods, and that $\hat{\beta}_{BRA} > 0$, i.e., branded stations charge higher prices than unbranded stations. Both of these empirical findings are quite intuitive in nature. We exclude station characteristics in the pricing regression in order to obtain the necessary exclusion restrictions for the switching regression model (see Maddala, 1983).

As regards the estimated coefficients of the self-selectivity variables, we find that the covariance between the single-product decision and the self-service price (α_{SP}) is negative, i.e., if a station is more likely to be single-product for some unobserved reasons, it is also more likely to charge a lower price for self-service gasoline. The covariance between the multi-product decision and self-service price ($\alpha_{\mathrm{MP,s}}$) is positive, i.e., if a station is more likely to be multi-product for some unobserved reasons, it is also more likely to charge a higher price for self-service gasoline. The covariance between the multi-product decision and full-service price ($\alpha_{\mathrm{MP,f}}$) is positive and quite large in magnitude, i.e., if a station is more likely to be multi-product for some unobserved reasons, it is also more likely to charge a much higher price for full-service gasoline.

The pricing regression represented by the model without self-selectivity correction, whose results are reported under the columns labeled W/O in Table 1, ignores the endogeneity of the variables $I_{MP,s}$ and $I_{MP,f}$ and treats them as being exogenously pre-specified. The implications of the price-discrimination model should manifest themselves in this regression model as $\hat{\beta}_{MP,f} > 0$ and $\hat{\beta}_{MP,s} < 0$. This is equivalent to what Shepard (1991) tests in her study. However, we find that $\hat{\beta}_{MP,s} > 0$, i.e., self-service gasoline is more expensive at a multi-product station than at a single-product station, all else being equal. This would lead one to reject the hypothesis of price-discrimination when, in fact, the results from the proposed regression model (represented under columns W) show that this is not the case! After modeling the endogeneity in the station type decision and explicitly correcting for the effects of such endogeneity in the pricing regressions—using the self-selectivity variables SS_{SP} and SS_{MP} and the self-selectivity parameters α_{SP}, $\alpha_{MP,s}$, $\alpha_{MP,d}$—we are able to (correctly) conclude that self-service gasoline is cheaper at multi-product stations (see results under columns labeled W). These results are consistent with the intuition provided earlier using Figure 1, and can be understood as follows: The unobserved correlation between the single-product decision and the self-service price is negative, while the unobserved correlation between the multi-product decision and the self-service price is positive. If these unobserved correlations are not accounted for in the

Table 3. Effects of income spread on price differentials.

Parameter	Low grade	Medium grade	High grade
Intercept	− 2.46	− 2.63	− 2.20
	(2.02)	(2.22)	(2.04)
$I_{MP,s}$	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
$I_{MP,f}$	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
$SPREAD^{*}I_{MP,s}$	**−0.01**	**−0.01**	**−0.01**
	(0.00)	(0.00)	(0.00)
$SPREAD^{*}I_{MP,f}$	**0.01**	**0.01**	**0.01**
	(0.00)	(0.00)	(0.00)
BRA	**2.04**	**2.16**	**2.13**
	(1.08)	(1.05)	(1.09)
AVG	**0.08**	**0.09**	**0.08**
	(0.05)	(0.04)	(0.05)
SS_{SP}	**−0.60**	**−0.63**	**−0.61**
	(0.36)	(0.40)	(0.35)
$SS_{MP,s}$	**1.98**	**1.96**	**2.06**
	(0.98)	(0.92)	(1.20)
$SS_{MP,f}$	**19.33**	**24.00**	**21.23**
	(4.99)	(5.43)	(5.21)
R-squared	0.12	0.15	0.12
Adjusted *R*-squared	0.10	0.12	0.10

Significant estimates in bold, standard errors within parentheses. Dependent variable: Price of gasoline. Number of observations: 258.

analysis, one is likely to conclude that self-service prices are higher at multi-product stations! This illustrates the consequences of ignoring the endogeneity of the station type decision on the estimated parameters of the pricing regression.[10]

Our theoretical model predicts that the magnitude of the three price differentials—$(P^{f}_{MP} - P_{SP})$,$(P^{s}_{MP} - P_{SP})$ and $(P^{f}_{MP} - P^{s}_{MP})$—will be higher in markets with greater income spreads. In order to test this implication, we introduce the following interaction terms—$SPREAD^{*}I_{MP,s}$ and $SPREAD^{*}I_{MP,f}$—as explanatory variables in the pricing regression, and test whether their estimated coefficients are as follows: $\hat{\beta}_{SPREAD^{*}MPf} > 0, \hat{\beta}_{SPREAD^{*}MPs} < 0$. The results of this regression are given in Table 3. We find that $\hat{\beta}_{SPREAD^{*}MPf} > 0, \hat{\beta}_{SPREAD^{*}MPs} < 0$, thus lending further empirical support to the implications of the theoretical model.

10 From Table 2 it might seem that the W/O regression obtains superior *R*-squared values than the W regression. However, the superior *R*-squared values in Table 2 are a consequence of station characteristics being used in the W/O pricing regression, as opposed to being excluded under the W pricing regression (where the excluded variables are used in the station type decision in Table 1). If we used identical explanatory variables under both specifications, the proposed model would indeed fit better on account of the additional self-selectivity variables.

4.2. The effect of branding on price discrimination

The results of the binary probit model in Table 1 show that $\eta_{BRAND} > 0$ for all three grades of gasoline, implying that a branded station is more likely to price discriminate by being a multi-product station. Thus a branded station is likelier to price discriminate. This result is consistent with the following natural extension of the theoretical model. Branding increases the consumer's valuation of any given level of service quality. Thus, for a given level of service quality, consumers would be willing to pay more at a branded station than at an unbranded station. Specifically, consider a modification to the consumer surplus function in Section 2 to $V = \gamma\theta s - p$. The parameter γ captures the effect of branding (a branded station is characterized by a higher γ) and it implies that for a given level of service quality, consumers are willing to pay more at a branded station than at an unbranded station. Note that the multiplicative formulation of the consumer's surplus function implies that in gasoline markets the effect of branding is higher for consumers with higher valuation of service quality. Thus consumers with higher income have greater willingness to pay not only for service quality but also for brand. An analysis similar to that in Section 2 shows that $\partial\Delta_\pi/\partial\gamma > 0$ or that price discrimination is more likely for a branded station.

The empirical result $\eta_{BRAND} > 0$ is consistent with this theoretical formulation of the effect of branding. The likelihood of being multi-product is higher for a branded gasoline station than for an unbranded gasoline station, all else being equal. While all consumers are willing to pay more for service at a branded station, the value of the brand name is higher for consumers who have a higher valuation for service. This increases the value (to the branded firm) of consumers who are at the higher end of the taste distribution. This means that between a branded and an unbranded station of identical self-service price and service levels, the branded station can charge a higher price for a given level of full-service gasoline. Thus price discrimination is more profitable for branded gasoline stations.[11]

Next, we investigate the effects of branding on prices and price differentials. Note that the theoretical difference between the multi-product full and the single-product price can be derived to be $p^f_{MP} - p_{SP} = \gamma^2 b(b-a)/4k$, while the difference between the multi-product self and the single-product price is $p^s_{MP} - p_{SP} = \gamma^2 a(a-b)/4k$. The multi-product self price is higher than the single-product price by a larger amount for a branded gasoline station than for an unbranded gasoline station. Similarly, the multi-product self-service price is lower than the single-product price by a larger amount for a branded gasoline station than for an

11 Png and Reitman (1995) find that stations selling premium gasoline, those offering repair service and those situated near highways are more likely to be branded. They argue that this is consistent with the idea that brands can act as signals of quality for experience goods. Our paper analyzes the relationship between branding and price discrimination incentives and this implies an examination of the relationship between branding and the choice of the station type.

Table 4. Effects of brand name on price differentials.

Parameter	Low grade	Medium grade	High grade
Intercept	– 2.18	– 2.29	– 1.87
	(1.97)	(2.16)	(1.99)
$I_{MP,s}$	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
$I_{MP,f}$	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
$BRA^{*}I_{MP,s}$	**−0.55**	**−0.61**	**−0.51**
	(0.39)	(0.32)	(0.22)
$BRA^{*}I_{MP,f}$	**5.61**	**5.55**	**5.97**
	(2.41)	(2.57)	(2.47)
AVG	**0.07**	**0.07**	**0.07**
	(0.03)	(0.04)	(0.04)
SS_{SP}	**0.17**	**0.13**	**0.19**
	(0.07)	(0.02)	(0.15)
$SS_{MP,s}$	**1.00**	**1.05**	**1.03**
	(0.54)	(0.49)	(0.55)
$SS_{MP,f}$	**20.23**	**24.74**	**21.25**
	(4.75)	(5.20)	(4.96)
R-squared	0.14	0.16	0.14
Adjusted *R*-squared	0.11	0.13	0.12

Significant estimates in bold, standard errors within parentheses Dependent variable: Price of gasoline, Number of observations: 258.

unbranded gasoline station. Finally, it can also be shown that for a multi-product station the difference between full- and self-service prices is larger if the station is a branded station.

In order to test the above prediction that the magnitude of the three price differentials $(P^{f}_{MP} - P_{SP})$,$(P^{s}_{MP} - P_{SP})$ and $(P^{f}_{MP} - P^{s}_{MP})$ must be greater for branded stations we introduce the following interaction terms—$BRA^{*}I_{MP,s}$ and $BRA^{*}I_{MP,f}$—as explanatory variables in the pricing regression and test whether $\hat{\beta}_{BRA^{*}MPf} > 0$,$\hat{\beta}_{BRA^{*}MPs} < 0$. The results of this regression are given in Table 4 and we find that $\hat{\beta}_{BRA^{*}MPf} > 0$,$\hat{\beta}_{BRA^{*}MPs} < 0$, thus lending further empirical support to the implications of the theoretical model.

4.3. *Other station characteristics*

The results of the binary probit model reported in Table 1 also indicate the effect of other station characteristics on the incentive to price discriminate. We find that gasoline stations with pay-at-pump facility are less likely to be multi-product, i.e., $\hat{\eta}_{PAY} < 0$. A possible reason for this finding is that newer stations are more likely than older stations to both have the pay-at-pump facility and be single-product

Table 5. Average income of local markets (in 000's of dollars).

Characteristic	Stations without characteristic	Stations with characteristic	Difference (*p*-value)
Pay-at-pump	35.57 (13.66)	37.97 (13.13)	– 2.40 (0.30)
	75	*123*	not significant
Convenience store	44.83 (17.62)	35.67 (11.97)	9.16 (0.006)
	30	*168*	significant
Service station	34.45 (10.92)	42.40 (16.10)	– 7.95 (0.001)
	133	*65*	significant

Standard errors within parentheses; number of stations in italics.

stations.[12] Another possible reason for this empirical finding may be related to the distortion-at-the-bottom result in the theory of second-degree price discrimination (see Tirole, 1988, p. 149). For example, in a version of our model where the number of consumer types and the number of products are the same, the point arises that a firm will distort downward the self-service quality that is offered to the low-type/income group[13] in order to prevent the high-income group from finding the self-service product to be too attractive. Doing this helps the station sustain a higher price for the full-service product. Our empirical finding about pay-at-pump may be consistent with the distortion-at-the-bottom result as follows: Given that consumers of full-service gasoline are assisted in their purchase process by station attendants, it seems reasonable to assume that the pay-at-pump facility is more valuable to consumers who decide to buy self-service gasoline than to consumers of full-service gasoline.[14] Since the pay-at-pump facility makes the self-service product more valuable, it makes it difficult for a multi-product station to sustain a higher price for the full-service product.

We also find that gasoline stations with convenience stores are less likely to be multi-product, i.e., $\hat{\eta}_{CONV} < 0$. This empirical finding is consistent with observations in previous research that newer stations are more likely than older stations to both have a convenience store and be single-product stations (Shepard, 1991). We can think of an alternative reason for this empirical finding. Convenience stores at gasoline stations have patronage from customers who buy cigarettes, soda or fast food while on the road. If these customers have lower-income, and are therefore more likely to be self-service customers, such a correlation-based explanation may be responsible for our empirical finding about the convenience store. We also find some

12 This explanation, however, leaves unanswered the question of why newer stations tend to be single-product stations.

13 The firm will offer these consumers a quality level that is less than socially optimal, i.e., a level that is less than that implied by equating the marginal valuation of quality to the marginal cost of quality.

14 Interviews that we conducted among managers/clerks at multi-product stations in Saint Louis that had the pay-at-pump indicated that self-service consumers, rather than full-service consumers, typically used this feature.

empirical support for this explanation in our dataset. Table 5 shows that gasoline stations with convenience stores are located in neighborhoods whose incomes are, on average, \$9160 lower than at other neighborhoods.

Lastly, we find that gasoline stations with service bays are more likely to be multi-product, i.e., $\hat{\eta}_{SERV} > 0$. One explanation for this finding is that full-service customers may be more willing than self-service customers (who are more price-sensitive) to patronize service bays at gasoline stations that are typically more expensive than stand-alone service bays.[15] We also find some empirical support for this explanation in our dataset. Table 5 shows that gasoline stations with service stations are located in neighborhoods whose incomes are, on average, \$7950 higher than incomes at other neighborhoods.

5. Conclusions and future research

This paper investigates a gasoline station's endogenous decision to price-discriminate across consumers in its local market. We generate predictions about a station's incentive to be single- or multi-product, and about the station's choice of conditional prices for its gasoline. The predictions are tested on data gathered from gasoline stations from the Greater Saint Louis area using a switching regression methodology that is estimated using a consistent two-step approach. We employ a binary probit framework that models a station's decision to price-discriminate through the choice of the station-type as a function of market and station characteristics. We then estimate conditional linear regressions with self-selectivity corrections for the station's choice of prices. We find that a pricing regression that does not endogenize the gasoline station's product decision to the characteristics of its market leads to incorrect inferences about the differences in the prices charged between single-product and multi-product stations. The analysis also allows us to link the incentive to price discriminate to the characteristics of the local market. Specifically, we find that a larger income spread in the market implies a greater likelihood of the gasoline station being multi-product.

Some additional directions exist for future research. It might be the case that other station characteristics are jointly endogenous with the station-type. Perhaps the most interesting decision to investigate in this context is the location decision of the station. The decision of a station to locate in a particular market would not only be related to the station-type decision examined in this paper, but also to other station decisions such as the choice of the convenience store, car wash and service station. In addition, correcting for the endogeneity of these other characteristics might also be necessary to obtain unbiased estimates of parameters associated with the exogenous variables (Villas-Boas and Winer, 1999).

15 For transmission services, for example, we found that service bays located in gasoline stations charged prices in the range of \$175–\$225, while stand-alone service bays charged prices in the range of \$125–\$175.

6. Appendix

In this appendix we report the empirical analyses after including the 13 single-product full-service stations in the dataset. Inspection of the tables below will show that all the results of the paper remain unchanged.

Table A1. Binary probit results.

Parameter	Low grade (211 stations)	Medium grade (186 stations)	High grade (209 stations)
Intercept	**−2.84**	**−2.41**	**−2.83**
	(0.73)	(0.81)	(0.73)
BASE	0.01	0.02	0.01
	(0.02)	(0.02)	(0.02)
SPREAD	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)
BRAND	**1.67**	**1.73**	**1.67**
	(0.46)	(0.52)	(0.46)
PAY	**−1.14**	**−1.37**	**−1.13**
	(0.46)	(0.52)	(0.46)
CONV	− 0.11	− 0.26	− 0.11
	(0.31)	(0.35)	(0.31)
WASH	− 0.32	− 0.02	− 0.31
	(0.34)	(0.34)	(0.35)
SERV	**1.98**	**2.24**	**1.98**
	(0.29)	(0.32)	(0.29)

Significant estimates in bold, standard errors in parentheses. Dependent variable: Whether or not station is multi-product (1 = Yes, 0 = No). Number of observations: 198.

Table A2. Results of pricing regression.

Parameter	Low grade	Medium grade	High grade
Intercept	**1.02**	**1.12**	1.22
	(0.03)	(0.03)	(2.00)
$I_{SP,F}$	**0.16**	**0.10**	**0.29**
	(0.06)	(0.05)	(0.05)
$I_{MP,S}$	**−0.08**	**−0.08**	**−0.06**
	(0.04)	(0.04)	(0.03)
$I_{MP,F}$	**0.40**	**0.36**	**0.40**
	(0.04)	(0.05)	(0.04)
BRA	**0.10**	**0.11**	**0.11**
	(0.02)	(0.03)	(0.02)
AVG	**0.002**	**0.002**	**0.002**
	(0.001)	(0.001)	(0.001)
SS_{SP}	**−0.04**	**−0.03**	**−0.03**
	(0.01)	(0.02)	(0.01)
$SS_{MP,s}$	**0.07**	**0.04**	**0.06**
	(0.03)	(0.02)	(0.03)
$SS_{MP,f}$	**0.03**	**0.06**	− 0.003
	(0.01)	(0.03)	(0.003)

Significant estimates in bold, standard errors within parentheses. Dependent variable: Price of gasoline. Number of observations: 258.

Table A4. Results of pricing regression that ignores the endogeneity of station type decision.

Parameter	Low grade	Medium grade	High grade
Intercept	**1.02**	**1.13**	**1.23**
	(0.04)	(0.04)	(0.04)
$I_{SP,F}$	**0.16**	**0.12**	**0.29**
	(0.06)	(0.06)	(0.06)
$I_{MP,S}$	**0.03**	**0.05**	**0.03**
	(0.01)	(0.02)	(0.02)
$I_{MP,F}$	**0.47**	**0.50**	**0.47**
	(0.04)	(0.04)	(0.04)
BRA	**0.09**	**0.10**	**0.10**
	(0.03)	(0.03)	(0.03)
AVG	**0.002**	**0.002**	**0.002**
	(0.001)	(0.001)	(0.001)
PAY	– 0.02	– 0.02	– 0.02
	(0.03)	(0.03)	(0.03)
$CONV$	0.002	– 0.01	– 0.002
	(0.03)	(0.03)	(0.03)
$WASH$	**0.07**	**0.06**	**0.06**
	(0.03)	(0.03)	(0.03)
$SERV$	**–0.07**	**–0.09**	**–0.06**
	(0.03)	(0.04)	(0.03)

Significant estimates in bold, standard errors within parentheses. Dependent variable: Price of gasoline. Number of observations: 258.

Table A3. Effects of income spread on price differentials.[16]

Parameter	Low grade	Medium grade	High grade
Intercept	**1.10**	**1.21**	**1.32**
	(0.03)	(0.03)	(0.03)
$SPREAD*I_{SP,F}$	**0.0005**	0.0001	**0.001**
	(0.0002)	(0.0004)	(0.0003)
$SPREAD*I_{MP,S}$	0.0001	0.0001	0.0002
	(0.0001)	(0.0001)	(0.0002)
$SPREAD*I_{MP,F}$	**0.002**	**0.002**	**0.002**
	(0.0002)	(0.0002)	(0.0002)
BRA	**2.04**	**2.16**	**2.13**
	(1.08)	(1.05)	(1.09)
AVG	0.001	0.001	0.0003
	(0.001)	(0.001)	(0.0009)
SS_{SP}	**0.01**	**0.02**	**0.02**
	(0.003)	(0.01)	(0.01)
$SS_{MP,s}$	**0.01**	**0.01**	– 0.007
	(0.002)	(0.004)	(0.005)
$SS_{MP,f}$	– 0.02	**0.03**	**0.003**
	(0.02)	(0.01)	(0.001)

Significant estimates in bold, standard errors within parentheses. Dependent variable: Price of gasoline. Number of observations: 258.

16 After introducing the interaction terms—$SPREAD*I_{MP,s}$ and $SPREAD*I_{MP,f}$—the main effects of $I_{MP,s}$ and $I_{MP,f}$ turned out to be insignificant. Therefore, they are suppressed in the regression whose results are reported in this table.

Table A5. Effect of brand name on price differentials.

Parameter	Low grade	Medium grade	High grade
Intercept	**1.04**	**1.16**	**1.25**
	(0.03)	(0.03)	(0.03)
$BRA{*}I_{MP,S}$	− 0.01	0.003	0.0004
	(0.03)	(0.004)	(0.0004)
$BRA{*}I_{MP,F}$	**0.50**	**0.43**	**0.48**
	(0.03)	(0.03)	(0.03)
AVG	**0.003**	**0.002**	**0.002**
	(0.001)	(0.001)	(0.001)
SS_{SP}	**0.02**	**0.03**	**0.05**
	(0.01)	(0.01)	(0.02)
$SS_{MP,s}$	**0.01**	**0.01**	**0.01**
	(0.001)	(0.02)	(0.002)
$SS_{MP,f}$	**0.19**	**0.16**	**0.22**
	(0.04)	(0.03)	(0.04)

Significant estimates in bold, standard errors within parentheses. Dependent variable: Price of gasoline. Number of observations: 258.

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