Price Dispersion and Accessibility: A Case study of Fast Food

Stewart, Hayden and Davis, David E.

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Hayden Stewart[*]

and

David E. Davis**

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Abstract

This study examines spatial variation in the price and accessibility of fast food across a major urban area. We use novel data on the price of a representative fast food meal and the location of fast food restaurants belonging to one of three major chains in the District of Columbia and its surrounding suburbs. These data are used to test a structural model of spatial competition. The results of this study are easily interpreted and compared with a past analysis. We find that spatial differences in costs and demand conditions drive variation in the number of firms operating in a market, which in turn affects prices.

Key Words: food prices, food accessibility, spatial competition, price dispersion, fast food

[*]Corresponding Author: Economic Research Service-USDA, 1800 M Street NW, Room N-2134, Washington, DC 20036-5831, USA. *Telephone:* (202) 694-5394, *e-mail*: hstewart@ers.usda.gov.

**Economic Research Service – USDA, 1800 M Street NW, Room N-2124, Washington, DC 20036-5831, USA *Telephone:* (202)-694-5382, *email:* ddavis@ers.usda.gov

1. Introduction

Who pays more for food? This question has been a subject of debate among researchers. Most focus on prices at supermarkets and other grocers, and ask whether retail food prices tend to be higher in markets with a greater proportion of lower income consumers, minority consumers, or consumers with some other trait. Recent studies include Frankel and Gould (2001), Hayes (2000), Kaufman *et al* (1997), as well as MacDonald and Nelson (1991). A few other studies have examined prices at restaurants, such as LaFontaine (1995), Graddy (1997), Jekanowski (1998), and Thomadsen (2003).

Being able to explain variation in average retail food prices could be useful for government agencies engaged in price measurement. However, it has also been a goal of researchers who are concerned with social equity. According to Graddy (1997), there is a perception that retailers engage in "unfair" commercial practices in lower income, minority neighborhoods, and she points out that retail establishments have been targeted during some riots in urban centers.

Empirical evidence does confirm some systematic dispersion of prices. According to Kaufman *et al* (1997), who conducted a review of fourteen prior studies, grocery prices tend to be higher in urban centers than in suburban markets. Some speculate that greater access to supermarkets in the suburbs is responsible. As compared with central city stores, supermarkets are argued to offer the lowest prices and the greatest range of brands, package sizes, and quality choices. MacDonald and Nelson (1991) find that a fixed market basket of goods costs about 4 percent less in suburban locations than in central city stores. However, they concede that their analysis is not based firmly in economic theory; rather it is only exploratory, owing to the lack of a precise model.

Studies have been less successful at explaining how and why prices might vary with the demographic characteristics of a market. First, recent studies of grocery prices have reached mixed results. For example, Hayes (2000) does not identify a statistically significant relationship between grocery prices and the income level of a market's residents. By contrast, Frankel and Gould (2001) find that prices are highest in markets with more income inequality. In other words, prices are found to be highest where there are more lower income or more higher income households. The lowest prices are found in markets with more consumers in between these two groups. Second, even when they are significant, there is the problem of interpreting estimation results. For example, the model of Frankel and Gould (2001) does not allow those authors to determine whether their findings are due to differences in consumer behavior, costs, or differences in the characteristics of stores and the quality of the services they provide.

Similar results have been obtained by researchers studying restaurant prices. For example, Graddy (1997) finds that prices are higher in neighborhoods with a higher proportion of Black and lower income consumers. However, her model does not identify whether the observed dispersion of prices stems from differences in costs and demand conditions, or whether it reflects discriminatory pricing strategies among retailers.

Utilizing a novel set of data on the price of a fast food meal and the location of fast food restaurants in a major urban area, this study tests the structural model of spatial competition developed by Salop (1979). Estimation results based on this model can be easily interpreted. According to this model, cost and demand conditions first determine how many stores choose to locate in a market. Holding all other factors constant, the more firms in a market, the greater access consumers will have to establishments on average. Greater access is defined to mean that consumers will have lower transportation costs and better substitutes for the services of any particular store. Stores will likewise have less market power and price more competitively.

This study focuses on fast food prices, because the authors believe such an analysis may be more easily undertaken than studies of grocery prices. Arguably, two different outlets affiliated with the same fast food chain supply relatively homogeneous goods and services. This fact may alleviate the possibility that differences in store formats are confounding the results of studies on grocery prices, such as central city stores being smaller or offering a narrower range of goods and services than suburban supermarkets[1].

The results of this study show that cost and demand factors influence prices through their effect on access. For example, consider a community where an increase occurs in demand, such as through an increase in the population or in the income of existing residents. Holding all else constant, this study finds that firms would likely respond by opening more outlets in the community. Consumers would then have more and better substitutes for the services of any particular store. In turn, restaurants would have more competitors, less market power, and charge slightly lower prices. In this way, low population levels and low levels of income might be associated with not only more limited access, but also higher prices. Moreover, we show that the reduced form of our model closely resembles the type of model estimated in past studies, including Graddy (1997), against which we compare our results.

[1] For example, in examining grocery prices, MacDonald and Nelson (1991) find it necessary to control for the type of retail format at which groceries are purchased. Variables include whether the retail store is a supermarket or a warehouse club, the size of a store in square feet, and the scope of services offered by a store such as whether there is a delicatessen, and a meat or seafood counter. By contrast, the authors feel that these types of variation do not confound analyses of fast food prices. Two McDonald's restaurants in separate locations have a relatively similar format and offer a relatively similar range of goods and services.

2. Theoretical Framework

In models of spatial monopolistic competition, consumers are dispersed over a market area that is represented with a line, circle, or other geometric form. Hotelling (1929) proposes a linear market, while Salop (1979) extends Hotelling's model and develops a circular market with an outside, homogeneous good. In that model, the homogeneous good is supplied by a competitive industry. In addition, there are also spatially dispersed firms, who share a common fixed cost, incur a constant marginal cost of production, and sell a second product. The supply of this second good is monopolistically competitive. A number of researchers have further expanded on models of spatial competition including work by Capozza and Van Order (1978), Capozza and Van Order (1980), MacLeod *et al* (1988), Rath and Zhao (2001), and Puu (2002).

In Salop's (1979) model, a consumer's costs for purchasing the second good include the retail price (i.e., the "mill" price) and his or her costs for transportation to a retail store.[2] It is assumed that only if the total cost of obtaining the second item is below the consumer's reservation cost will the consumer purchase a given number of units of this good.[3] The consumer will buy only the homogeneous good otherwise. Significant transportation costs can therefore prevent suppliers of the second good from concentrating all of their production in one location. Customers may incur a prohibitively large cost for travel to this concentrated site.

[2] It is assumed that there is no price discrimination; rather all consumers pay the same mill price. For a discussion of price discrimination, see MacLeod *et al* (1988). They derive the subgame perfect equilibrium in a two-stage game in which firms are allowed to adjust their mill prices according to a consumer's costs for transportation. It is shown that firms may charge higher prices to their nearest consumers. The reason is that these consumers consider farther away stores a relatively poor substitute for their nearest store. Such consumers face a relatively high cost differential for traveling to their nearest store and the next nearest one. By contrast, this cost differential is relatively small for consumers who are located a relatively far distance from any store.

[3] Salop claims that his model can be readily extended to consider elastic demand. For example, see Puu (2002) as well as by Rath and Zhao (2001), who demonstrate the equilibria in models of a linear market.

Competition among suppliers of the second good is imperfect in the model of Salop (1979). Because they incur a non-zero cost of transportation, consumers prefer to patronize the nearest firm if mill prices are equal. The demand for goods from firm i is then a function of the price of i and the price of all other firms who are sufficiently close to i. Using this model, Salop (1979) derives the demand schedule facing a representative firm, and shows that prices for the second good are a function of transportation costs due to their impact on a firm's market power.

Prices for the second good may decrease with the number of firms in a market under some assumptions about firm behavior. Salop (1979) shows that, as the number of firms in a market increases, each firm will be spatially closer to one of its rivals. Consumers may have more and better substitutes for the goods offered by any single firm. In general, the price charged by firm i will move closer to i's marginal cost. A necessary assumption about firm behavior is that each firm chooses a best price, given the perception that all other firms hold their prices constant.[4] Empirical evidence that prices tend to decrease with the number of firms in a market has been provided by Bresnahan and Reiss (1991).

The number of firms in a market is determined in advance of prices. In the model of Salop (1979), just enough firms enter a market so that, once prices are later determined, economic profits will be zero.[5] The resulting equilibrium is termed a symmetric zero profit Nash equilibrium. For instance, given a distribution of firms who are poised to make zero economic profits, a decrease in fixed costs or an increase in demand would allow for positive economic profits. New firms will then enter the market, and, in turn, each firm's market share will

[4] Capozza and Van Order (1978) present a general case allowing for a wider range of assumptions about firm behavior.
[5] Firms in the model of Salop (1979) are "portable." As further argued in Capozza and Van Order (1980), portability requires that firms can relocate when new firms enter a market. However, if existing firms are immobile, then this equilibrium condition must be restated such that firms will enter a market if and only if they can expect to make positive economic profits. In other words, entry is sequentially rational.

decrease. Expected profits then fall with market shares. This process will continue until all firms can once again expect to earn only a zero economic profit.

In this study, we use the model of Salop (1979) to motivate a system of structural equations which serve as the basis for an empirical analysis. We assume that there are M circular markets and consumers in each market are spatially dispersed. We denote the aggregate demand of consumers in each of these markets, m=1,…,M, as D_m. We allow D_m to vary with the number of consumers in each market. Moreover, we allow the demand for fast food to depend on the social and demographic characteristics of the consumers. However, for prices below the consumer's reservation cost, quantity demanded does not vary with price; rather consumer demand is inelastic. Consumers pay the retail price and incur a non-zero cost for traveling to restaurants. In market m, let the number of restaurants be N_m and all other factors that influence transportation costs be T_m. There is free entry and N_m is determined such that economic profits are zero. Also, we assume that the fixed cost associated with operating a restaurant varies across markets, but not within markets. Let this fixed cost in market m be C_m.

Continuing to follow Salop (1979), we hypothesize that N_m is decreasing in C_m but increasing in D_m and T_m. Thus, our model of N_m is

$$N_m = N(\overset{-}{C}_m, \overset{+}{D}_m, \overset{+}{T}_m)\,. \tag{1}$$

Similarly, we allow for the possibility that prices in a market depend upon the marginal costs of firms in that market (MC_m) as well as N_m and T_m. The price of a meal in market m, P_m, is then

$$P_m = P(\overset{+}{MC}_m, \overset{+}{T}_m, \overset{-}{N}_m)\,. \tag{2}$$

where (1) and (2) represent a system of simultaneous (triangular) equations.

Finally, if one desires, we note that (2) can be substituted into (1) to obtain a reduced form equation for fast food price,

$$P_m = P(MC_m, \overset{+}{T}_m, \overset{+/-}{C}_m, \overset{+/-}{D}_m) \quad (3)$$

where N_m no longer appears as a separate regressor. This equation approximates the reduced form model used in Graddy (1997).[6]

4. Data and Empirical Model

We next document our data sources and develop an empirical representation of the equations in the previous section. We collected data on the prices and locations of McDonald's, Burger King, and Wendy's restaurants in the District of Columbia and its surrounding suburbs.[7] We identified stores using local telephone directories, web-based telephone directories, and company websites.[8] In total, we identified 328 restaurants and collected price information on 253 of them during the late Summer and Fall of 2002.[9] At each of these stores, we recorded the price of a number one value meal which includes a hamburger sandwich, a soda, and fries. Among McDonald's and Burger King restaurants, value meals were sold in medium, large, and extra-large sizes. We priced the large size. However, among Wendy's restaurants, value meals were sold in only two sizes, a regular size and Biggie™. We priced the regular size. Finally, we

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[6] Following the notation in this study, the dependent variable in the model of Graddy (1997) is the price of food at restaurant i in zip code m. A notable difference between this specification and that of Salop (1979) is that the model of Graddy (1997) treats individual stores as the level of analysis, not the market. Explanatory variables in the model of Graddy (1997) include a few store-specific controls, such as the number of employees, as well as many zip code-level proxies for costs, the competitive environment, and the demographic characteristics of that zip code's residents, such as their race and income level.

[7] These suburbs include Montgomery and Prince George counties in Maryland as well as Fairfax County, Arlington County, and Alexandria City in Virginia.

[8] Each of the three fast food chains under study has a restaurant locator on their website.

[9] We collected prices by visiting restaurants and by phoning restaurants. Among restaurants contacted by telephone, unusual price information was confirmed by re-phoning or visiting the establishment. Collecting accurate price data by telephone can be problematic. Graddy (1997) used data collected by Card and Krueger (1994), and notes how other researchers have found problems with these data. She cites one researcher, Lavin (1995), who comments that restaurant employees do not appear to have always given accurate price data. For instance, some employees at Burger King restaurants may have reported the price for a "Whopper" when asked for the price of a regular

supplemented our price and location data with information on the economic and demographic characteristics of the zip codes in which restaurants are located. Some of these data were taken from Census 2000, including the number of people living in the zip code, the racial and ethnic characteristics of residents, the median household income, the average age of residents, and the proportion of households containing children. Other data were taken from Realtor.com, a website with real estate listings, including the median value of homes in a zip code. Finally, we obtained data on the size of each zip code in square miles from the ArcView™ software package. Complete data could be collected for 97 zip codes in which we also had located restaurants.[10]

As an initial step, we demonstrate that there exists a dispersion of prices and accessibility in the region under study. Table 1 shows that the mean number of restaurants belonging to one of the three chains was 3.08 with a standard deviation of 1.68 among the 97 zip codes used in our analysis. As for price dispersion, Figure 1 further shows the distribution of prices at McDonald's and Burger King establishments in our sample. Sampled restaurants affiliated with McDonald's were frequently charging $4.09 or $4.19 for a large, number one value meal. At the same time, other stores were selling this same meal for as little as $3.89 and as much as $4.56. Similarly, restaurants affiliated with Burger King were frequently found to be charging $4.79 for their large, number one value meal. However, we also observed prices as low as $4.29 and as high as $5.09. By contrast, among restaurants affiliated with the Wendy's chain, all sampled establishments were charging $3.99 for a regular, number one meal[11].

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hamburger. We formulated our sampling strategy to minimize this problem. However, because of time constraints, we ultimately could not obtain reliable price data on all establishments.

[10] For some markets, in which we had identified restaurants, we could not obtain pertinent data about the zip code, such as the cost of a home. In fact, there were 300 restaurants in the 97 zip codes for which we also had complete data. Our price data covered 240 of these 300 establishments.

[11] This result might surprise some readers who would expect to pay the same price at two restaurants affiliated with the same chain. However, it is important to consider that most fast food restaurants are owned and operated by franchisees. Moreover, resale price maintenance is illegal in the United States. In other words, large restaurant companies have direct control over prices at only company-owned outlets. Franchisees are free to set their own

Following Graddy (1997) and LaFontaine (1995), we next assume that separate zip codes are separate markets.[12] For each market, we calculate the average price (without tax) of a meal, P_m, as well as the number of restaurants affiliated with any of the three restaurant chains, N_m.[13] These two variables serve as the dependent variables in our analysis.[14]

Among the explanatory variables in the empirical specification of our model, we proxy for fixed costs, C_m, in equation (1) with the median price of a house, measured in hundreds of thousands of dollars, HOUSE. We hypothesize that the number of restaurants in a market is decreasing in fixed costs, and therefore, HOUSE.[15] We also include several variables in (1) to account for aggregate demand, D_m. Demand is thought to depend upon the number of consumers in the market and so we include the zip code population in tens of thousands of people, POP. Following Stewart *et al* (2004), Byrne *et al* (1998), and McCracken and Brandt (1987), we also include variables shown to influence per capita spending on fast food. These include the median

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prices. While LaFontaine (1995) finds that prices vary even across company-owned stores, price dispersion is greatest among establishments owned by franchisees.

[12] The use of zip codes to proxy for markets is admittedly imperfect. Instead of assuming a zip code to approximate a market, Thomadsen (2003) treats the size of a market as endogenous. That model facilitates his analysis of price competition among restaurants. However, the model of Thomadsen (2003) focuses on the second stage of a location-price game. In other words, he analyzes the prices charged by firms, given that they have entered the market. He does not consider how access to fast food can vary with the demographic characteristics of a market's residents, such as their income level, or the determinants of fixed costs in a market, such as the cost of housing.

[13] As mentioned earlier, we could not obtain price data on all restaurants in all zip codes. In these cases, P_m is the average price of a meal at restaurants from which prices were obtained. However, N_m remains the number of restaurants in the zip code, regardless of whether price data were obtained on each establishment.

[14] As noted in footnote 6, unlike Graddy (1997), we aggregate our data to the zip code-level. We feel that this approach better reflects the model of Salop (1979), which is of a market, not of a firm. Moreover, as discussed below, our independent variables include the income level of a market's residents, the number of people living in a market, and other characteristics of the market in which a restaurant is located. It follows that there is almost no variation in the value of the independent variables associated with different stores in the same zip code. Only if two stores in the same zip code belong to different chains, could there be some variation in the value of an indicator variable for store-affiliation. Moulton (1986) has shown that estimation, using a cross-section of data in which many observations share the same (or similar) values for their independent variables, can lead to a serious underestimation of the standard errors on the coefficients. Aggregating data to the zip-code level further removes this possibility.

[15] In the estimation of the model, we also experimented with separate dummy variables for whether a restaurant was located in the District of Columbia, Montgomery County, Prince George County, Fairfax County, Arlington County, or Alexandria City. The reason is that insurance rates tend to vary by county and past researchers have asked whether these rates impact fixed costs. However, in our study, these variables were never significant nor did they influence the sign and significance of the other variables in the model.

income of residents measured in tens of thousands of dollars (INCOME), the median age of residents (AGE), and the proportion of households with a child (KIDS).

We also use several variables to proxy for factors other than N_m thought to affect the cost of transportation in a market, T_m.[16] In particular, it is hypothesized that residents of rural, suburban, and urban areas may have different costs for transportation. Some rural areas are geographically larger than urban ones. Holding all else constant, it follows that residents of rural areas may tend to travel farther distances than their urban counterparts. However, residents of urban areas may be less likely to own a car and, if they do drive, have more difficulty parking or face more congested roads. Thus, we created dummy variables to proxy for the three types of community. RURAL = 1 for markets outside the Beltway with fewer than 1,500 residents per square mile, and RURAL = 0 for all other zip codes[17]. CITY is coded similarly except that it identifies inner-city markets with more than 9,000 residents per square mile inside the Beltway. Including these two variables in the model, we contrast areas classified as RURAL and CITY with more suburban communities, SUBURBAN, the reference market.

In the empirical specification of (2), we include N_m, RURAL and CITY to control for transportation costs, T_m, as well as other variables to account for differences in marginal costs, MC_m. Variables controlling for marginal costs include three binary indicators of the county in which a zip code is located. These are MNT = 1 if the market (zip code) is in Montgomery County, MD, and 0 otherwise; VA=1 if the market is anywhere in Virginia, and 0 otherwise; PG=1 if the market is in Prince George's County, MD, and 0 otherwise.[18] Markets in the District

[16] We also tried using the proportion of residents without a car in our model. However, it was highly collinear with INCOME as well as the variables RURAL and CITY, discussed in this paragraph.
[17] The Beltway is a highway encircling the District of Columbia and its inner suburbs.
[18] In place of VA, we also tried using separate indicator variables for Fairfax County, Arlington County, and Alexandria City. These places are all in Virginia. However, with the exception of Fairfax County, they are also relatively small in geographic terms. Likewise, we had few observations for Arlington County and Alexandria City,

of Columbia, DC, serve as the reference market. Marginal costs can be expected to vary by county, because the counties have different sales tax rates and, very likely, different wage rates.

We also allow marginal costs to vary across chains. The marginal cost at McDonald's may differ from that at Burger King, for example. If so, because we aggregate our data to the zip code level, it follows that the average level of marginal costs in a zip code will depend upon the portion of all restaurants belonging to each chain. Thus, we include in MC_m the proportion of restaurants used in the calculation of P_m belonging to McDonald's (MCD), Burger King (BK), and Wendy's (WNDY).

We assume a linear relationship between variables, and substituting the relevant variables into equations (1) and (2) yields the following set of triangular equations:

$$N = a_0 + a_1 CITY + a_2 RURAL + a_3 HOUSE + a_4 INCOME + a_5 KIDS + a_6 AGE + a_7 POP \quad (4)$$

$$P = ß_0 + ß_1 MNT + ß_2 VA + ß_3 PG + ß_4 WNDY + ß_5 BK + ß_6 CITY + ß_7 RURAL + ß_8 N. \quad (5)$$

Appending (4) and (5) with stochastic error terms creates the equations that are the basis for our econometric analysis. If these error terms have zero covariance, then performing ordinary least squares (OLS) on each equation separately will provide consistent estimates of the parameters ($a_0 - a_7$, $ß_0 - ß_8$). However, the estimated parameters in (5) will be inconsistent otherwise (e.g., Lahiri and Schmidt, 1978). Hausman (1978) demonstrates that his test for misspecification is appropriate to test for zero covariance between the error terms. For this study, we performed the version of the Hausman test proposed by Davidson and MacKinnon (1993). We used POP,

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which may help to explain why these variables were never individually statistically significant. For example, our data include only three zip codes in Arlington County.

HOUSE, INCOME, AGE, and KIDS as instruments for N. We assume these instruments to be related to N, but any linear combination of them to be exogenous to P. We failed to reject the null hypothesis that OLS provides consistent estimates of the parameters in (5). The coefficient on the first stage residuals was 0.0036 with a standard error of 0.0137 (P-Value = 0.7917).

Estimating the triangular system of equations (4) and (5) using a seemingly unrelated regressions (SUR) procedure is an unrestricted approach compared with estimating each equation separately by OLS. Moreover, it has been shown that, even if N were endogenous in the equation for P, *iterated* SUR will provide consistent and efficient parameter estimates, "ignoring the simultaneity" Greene (pg. 736-37). This result is attributed to Lahiri and Schmidt (1978). Thus, we estimated (4) and (5) using an iterated SUR procedure.[19]

A second consideration was the potential for collinearity among explanatory variables. Graddy (1997) encountered this problem and concedes that it may have affected some of her estimation results. Indeed, in this study, there is also a significant correlation among many of the proxies for costs and demand conditions. A correlation matrix is provided in Table 2. Among variables sharing a potentially troublesome correlation, for example, are INCOME and HOUSE. Housing prices tend to be greater in markets with higher income households.

Because multicollinearity between explanatory variables can affect estimation results (Greene, 1997), we report results from entering transportation cost, marginal cost, fixed cost, and demand variables sequentially in Table 3. The first pair of columns contains estimation results when only transportation costs are included in the model. The second pair of columns provides the estimated coefficients and their standard errors, when variables controlling for marginal costs are added to those for transportation costs. By contrast, the third, fourth, and fifth pairs of

[19] To be sure, estimation by OLS, iterated SUR, and even two-stage least squares (TSLS) yielded similar results. OLS and TSLS results are available from the authors upon request.

columns contain all variables in the structural model except proxies for demand conditions, fixed costs, and marginal costs, respectively. Estimation results for the full empirical model that most closely approximates the structural model of Salop (1979) are contained in the sixth pair of columns in Table 3.

Finally, we supplement the model in specification 6 with BLACK and HISPANIC which measure the proportion of households considering themselves to belong to each group, and are derived from Census 2000.[20] While not strictly suggested by Salop's theoretical model, we include them in our empirical model for the sake of comparison with past studies and to determine whether some form of price discrimination might be taking place. These estimation results are presented in the Table 4.

5. Findings

The data appear to fit the model well. As shown in the first five pairs of columns in Table 3, coefficients on explanatory variables change little in sign or magnitude across specifications. Note that INCOME is not statistically significant when HOUSE is not included (specification 4). Because the variables INCOME and HOUSE are positively correlated, but their coefficients have opposing signs in theory, it is likely that without HOUSE, INCOME is biased toward zero. For the empirical specification that most closely approximates Salop's theory, as shown in the final pair of columns in Table 3, the value of R^2 in the equation for N is

[20] It could be argued that these racial and ethnic variables belong among the proxies for demand conditions. However, Stewart *et al* (2004), Byrne *et al* (1998), and McCracken and Brandt (1987) do not find a statistically significant relationship between being Black and a household's spending for fast food. However, Byrne *et al* (1998) and Stewart *et al* (2004) find that Hispanic households may have a slightly elevated demand for fast food.

0.338 and that in the equation for P is 0.708.[21] We now examine the results for this specification, and then consider the impact of supplementing the empirical specification of our structural model with racial and ethnic variables.

Among our estimation results for equation (4), we find that the number of restaurants in a market is decreasing in fixed costs, as the coefficient on HOUSE is negative and significant at the 5 percent level. In particular, we find that an increase in the median price of a home of $100,000 will cause a market to have about 0.33 fewer restaurants. Theoretically, if fixed costs rise and demand is held constant, there is a decrease in the number of restaurants who can make a normal economic profit in a market.

There is also empirical evidence that the number of restaurants is increasing in the aggregate demand for fast food. For example, the coefficient on POP is positive and significant at the 5 percent level. An increase in population size of 10,000 people will cause the number of fast food restaurants in a market to rise by about 0.7 establishments. INCOME is also statistically significant at the 10 percent level, if we control for HOUSE. In general, if demand rises and fixed costs are held constant, there is an increase in the number of restaurants that can make a normal economic profit in a market. To be sure, this result is best interpreted as a short-run effect. It is unlikely that, in the long run, real estate prices would remain constant following an increase in a market's population or in the income of its residents.

The results may be better understood with a simple example. Consider the number of restaurants in zip code 20837, Poolesville, and in zip code 20705, Beltsville. Both communities are relatively large when measured in total area. Poolesville occupies 43.29 square miles of

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[21] Calculated for each equation using the estimated SUR coefficients. As shown in Table 3, the resulting values of R^2 do not necessarily decrease for both equations, if a variable is removed from the model. This counter-intuitive result can occur because we are minimizing the generalized sum of squares, and is among the many short-comings associated with measures of R^2 in generalized linear models (e.g., Greene, 1997).

suburban Maryland while Beltsville accounts for 19.23 square miles. However, a retailer's fixed costs are likely to be higher in Poolesville. The median value of a home is about $265,000 in Poolesville as compared with about $146,000 in Beltsville. Demand may also be greater in Beltsville where about 23,000 people live. The total population of Poolesville is just 6,000. The implication is that, although Beltsville is smaller in area, its lower fixed costs and higher aggregate demand support five of the selected fast food establishments, while market characteristics in Poolesville support only one.

Our estimation results for equation (5) (specification 6, column P) suggest that the average price of fast food is decreasing in the number of restaurants. The coefficient on N_m is negative and statistically significant at the 5 percent level. The entry of a firm into a market brings down the average price of a meal by about $0.02. However, arguably, this change in price is small relative to the total price of a meal. On this matter, our study appears to agree with Graddy (1997) who finds that restaurants in markets with three or fewer fast food outlets charge about 2.4 percent more than stores in zip codes with four or more outlets.

It further follows from the statistical significance of the coefficient on N_m in equation (5) that a relationship exists between prices and spatial differences in costs and demand conditions. We can calculate the marginal effect of a variable in equation (4) on the price. First consider the marginal effect of HOUSE. Theory predicts that increases in fixed costs should drive firms out of a market and prices may go up. In fact, we find that

$$\frac{\partial P}{\partial N}\frac{\partial N}{\partial HOUSE} = (-0.0190)(-0.3315) \approx 0.0063.$$

A $100,000 increase in the median price of a home implies an increase of almost $0.01 in the average price of a meal. Furthermore, using the means presented in Table 1, it is possible to calculate the elasticity of price with respect to the median cost of housing. Doing so, we find that a 10 percent increase in median housing prices causes a 0.04 percent increase in fast food prices. Similarly, it could be asked whether prices are relatively higher in lower income neighborhoods. That is, the marginal effect of INCOME is, i.e.,

$$\frac{\partial P}{\partial N}\frac{\partial N}{\partial \text{INCOME}} = (-0.0190)(0.2788) \approx -0.0053.$$

In words, a \$10,000 increase in the median income of a market's residents will cause the average price of a bundled meal to decrease by less than \$0.01. As measured in terms of an elasticity, a 10 percent increase in the median income of households is associated with a 0.08 percent decrease in fast food prices.

Our results further appear to agree with Graddy (1997) on the marginal effects of INCOME and HOUSE. Graddy (1997) also finds that prices are increasing with the cost of housing and, controlling for housing costs, decreasing in the median income of residents. For instance, in some specifications of her model, Graddy (1997) finds that a 10 percent increase in the median income of a zip code's residents is associated with a 1.57 percent decrease in the price of a fast food meal.

On the subject of the racial and ethnic composition of markets, our study does not agree with the results of Graddy (1997). As shown in Table 4, when racial and ethnic variables are added to our model, controlling for costs and demand conditions, we find no evidence that prices are higher, or access is more limited, in neighborhoods with a greater proportion of minority residents. The coefficients on BLACK and HISPANIC are not statistically significant. There are several possible explanations for why the two studies differ on this result. Arguably, because both analyses are case studies of two different urban areas, each could be a regional phenomenon. For example, there could be differences in how racial and ethnic variables happen to be correlated with proxies for costs or demand conditions, which we have found to influence the number of firms in a market.[22]

While many of our results agree with those of Graddy (1997), we believe it is interesting to compare the results of estimating our empirical specification of (1) and (2) simultaneously with results of estimating an empirical specification for our reduced form equation (3), when the racial and ethnic variables, BLACK and HISPANIC, are again included in the model. As shown in table 5, the direction of the marginal effects on key variables does not change. However, we find that fewer of the variables are statistically significant. For instance, the estimated coefficient on HOUSE is positive while the coefficients on INCOME and POP are negative. However, only HOUSE and POP are significant at the 5 or 10 percent levels, while INCOME becomes insignificant. Arguably, the greater shortcoming associated with estimating a reduced form model is that this approach provides no insights into why fast food prices are lower in communities with less expensive housing or greater population levels. In contrast, our structural equations clearly show the mechanism at work.

6. Conclusions

We utilize a unique set of data to estimate a model of accessibility and pricing among fast food restaurants in metropolitan Washington, DC. We find that the socio-demographic profile of a community influences the number, and therefore the accessibility, of fast food restaurants in that market, and prices may move slightly through spatial differences in access. We also compare our results on price dispersion with the findings of a past study. In general, we find quite a lot of

[22] In fact, Graddy (1997) concedes that the inclusion of racial variables in her model affects the significance of some proxies for costs.

agreement between our study and the past analysis. One notable exception is the effect of race and ethnicity.

The model tested in this study allows for a much richer interpretation of the results than do models tested in past analyses. As a final illustrative exercise, we consider two hypothetical markets and assume that consumers in both markets have the same aggregate demand for fast food, but fixed costs are higher in one market than in the other. We denote these markets as the "high-cost" and "low-cost" markets respectively. Next, assuming all else constant, we use the results of this study to argue that N is decreasing in C, i.e., $N_{High-Cost} < N_{Low-Cost}$. It follows that individual firms in the high-cost market are likely serving more meals than individual firms in the low-cost market. Recall our assumption that firms incur a constant marginal cost of production. Based on this assumption, it follows that the average cost of production will decline with output. As such, it is possible that firms in the high-cost market have about the same average cost as firms in the low-cost market. The former spread these fixed costs over more meals. Finally, because price equals average cost is an equilibrium condition, it follows that prices need not vary much with fixed costs. It would be sufficient that the number of firms varies, thereby explaining the findings of this study and other researchers of little variation in average prices with proxies for costs and demand.

However, even if the impact is small, we do find that average prices vary with fixed costs and demand. Continuing with our above example, we know that consumers in the high-cost market will have less access, continuing to hold all other factors constant. In turn, restaurants in the community have fewer competitors and, thus, more market power. To be sure, we again note that the extent of this later impact appears to be small. Prices move only slightly with differences in accessibility.

This study has examined accessibility and pricing for fast food, because the authors believe that such an analysis may be more easily undertaken than studies of grocery prices. However, it follows that the results of this study cannot be readily extended to explaining the conduct of supermarkets or even other types of restaurant, such as full-service ones. That would require controlling for differences in store formats and differences in the qualities of goods sold. Therefore, a goal of future analysis might be to incorporate such factors into a structural model of monopolistic competition whose results are easily interpreted.

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Table 1.
Means, Standard Deviations, and Definitions of Variables

VARIABLE	MEAN	ST. DEV.	DEFINITION
ENDOGENEOUS :			
P	4.2216	0.1741	Average price of a meal among sampled establishments
N	3.0825	1.6812	Number of restaurants belonging to one of three chains under study
FIXED COSTS:			
HOUSE	2.5273	1.5164	Median price of home ($100,000)
DEMAND CONDITIONS :			
POP	2.7854	1.3530	Number of Residents (10,000 people)
INCOME	6.5029	2.2998	Median Household Income ($10,000)
AGE	35.4718	3.8933	Median Age of Residents
KIDS	0.2838	0.1025	Proportion of Households with Live-at-Home Children
OTHER TRANSPORTATION COSTS :			
RURAL	0.1237	0.3310	Equals 1 if outside Beltway and residents per sq. mile < 1,500 ; 0 otherwise
CITY	0.1237	0.3310	Equals 1 if within Beltway and residents per sq. mile > 9,000 ; 0 otherwise
SUBURBAN	0.7526	0.4338	Omitted reference
MARGINAL COSTS:			
MNT	0.2474	0.4338	Equals 1 if Montgomery County, MD; 0 otherwise
PG	0.2371	0.4276	Equals 1 if Prince George's County, MD; 0 otherwise
VA	0.3402	0.4762	Equals 1 if Virginia; 0 otherwise
DC	0.1753	0.3822	Omitted reference
WNDY	0.1359	0.1951	Proportion of Restaurants Belonging to Wendy's in Calculation of P
BK	0.1336	0.2439	Proportion of Restaurants Belonging to Burger King in Calculation of P
MCD	0.7305	0.2843	Omitted Variable
RACE and ETHNICITY:			
HISPANIC	0.1045	0.0837	Proportion of Residents Considering Themselves to be Hispanic
BLACK	0.2993	0.2944	Proportion of Residents Considering Themselves to be Black

Table 2.
Unconditional Correlation Matrix, Selected Independent Variables

	RURAL	CITY	POP	INCOME	KIDS	AGE	HOUSE	BLACK	HISPANIC
RURAL	1.0000								
CITY	-0.1412	1.0000							
POP	-0.2831	0.0393	1.0000						
INCOME	0.1320	-0.4044	-0.0129	1.0000					
KIDS	0.3671	-0.3938	0.1825	0.4651	1.0000				
AGE	-0.0151	-0.1824	0.0154	0.6553	0.1174	1.0000			
HOUSE	-0.1052	-0.0636	-0.0154	0.6961	-0.0105	0.5596	1.0000		
BLACK	0.0946	0.1683	0.2523	-0.5503	0.0319	-0.2344	-0.4776	1.0000	
HISPANIC	-0.2489	0.2522	0.0333	-0.2548	-0.2020	-0.2221	-0.1386	-0.3066	1.0000

Table 3.
Estimated Coefficients, Standard Errors, and Measures of Goodness-of- fit[a]

	Spec. 1		Spec. 2		Spec. 3		Spec. 4		Spec. 5		Spec. 6	
	N	P	N	P	N	P	N	P	N	P	N	P
INTERCEPT	3.1096*	4.2605*	3.1096*	4.2001*	3.8211*	4.3165*	8.0686*	4.1845*	7.3575*	4.2865*	7.4548*	4.2056*
	(0.1982)	(0.0374)	(0.1982)	(0.0333)	(0.3182)	(0.0341)	(1.6344)	(0.0334)	(1.6120)	(0.0374)	(1.6184)	(0.0334)
MNT				0.0641**		0.0650**		0.0606**				0.0664**
				(0.0357)		(0.0354)		(0.0357)				(0.0357)
VA				-0.0052		-0.0048		-0.0048				-0.0047
				(0.0324)		(0.0320)		(0.0324)				(0.0324)
PG				0.0604**		0.0746**		0.0576				0.0624
				(0.0377)		(0.0376)		(0.0377)				(0.0377)
WNDY				-0.1953*		-0.1805*		-0.2026*				-0.1921*
				(0.0578)		(0.0574)		(0.0577)				(0.0578)
BK				0.4769*		0.4732*		0.4773*				0.4760*
				(0.0432)		(0.0428)		(0.0431)				(0.0432)
CITY	0.1404	0.1413*	0.1404	0.1238*	0.0416	0.1344*	-0.4900	0.1211*	-0.2276	0.1424*	-0.2414	0.1254*
	(0.5276)	(0.0523)	(0.5276)	(0.0355)	(0.5149)	(0.0409)	(0.5057)	(0.0356)	(0.5117)	(0.0525)	(0.5122)	(0.0355)
RURAL	-0.3596	-0.0118	-0.3596	-0.0625**	-0.5035	-0.0810*	0.7076	-0.0585**	0.6094	-0.0148	0.6203	-0.0642**
	(0.5276)	(0.0524)	(0.5276)	(0.0325)	(0.5162)	(0.0384)	(0.5199)	(0.0326)	(0.5137)	(0.0526)	(0.5141)	(0.0325)
N		-0.0178**		-0.0167*		-0.0559*		-0.0197**		-0.0262*		-0.0190*
		(0.0102)		(0.0063)		(0.0062)		(0.0063)		(0.0102)		(0.0063)
HOUSE					-0.2697*				-0.3496*		-0.3315*	
					(0.0959)				(0.1620)		(0.1627)	
POP							0.0623*		0.0649*		0.6511*	
							(0.0122)		(0.0120)		(0.1203)	
INCOME							0.0100		0.0284*		0.2788**	
							(0.0102)		(0.0141)		(0.1415)	
KIDS							-0.0490*		-0.0638*		-0.0636*	
							(0.0196)		(0.0212)		(0.0213)	
AGE							-0.1693*		-0.1490*		-0.1523*	
							(0.0522)		(0.0514)		(0.0516)	
R^2	0.006	0.100	0.006	0.708	0.068	0.572	0.309	0.683	0.338	0.093	0.338	0.708

* = statistically significant at the 5 percent level, ** = statistically significant at the 10 percent level.

Notes: a) R^2 calculated using the estimated SUR coefficients. Because we are minimizing the generalized sum of squares, the value of R^2 does not necessarily decrease for both equations, if a variable is removed from the model. This counter-intuitive result is among the many short-comings associated with R^2 in generalized linear models (e.g., Greene, 1997).

Table 4.
Estimated Coefficients and Standard Errors, including Race and Ethnicity

	N	P
INTERCEPT	8.1717* (1.6919)	4.2217* (0.0394)
MNT		0.0473 (0.0393)
VA		-0.0251 (0.0376)
PG		0.0711** (0.0399)
WNDY		-0.1873* (0.0585)
BK		0.4779* (0.0433)
CITY	-0.1472 (0.5235)	0.1312* (0.0393)
RURAL	0.4879 (0.5303)	-0.0621** (0.0335)
N		-0.0159* (0.0063)
HOUSE	-0.3304* (0.1635)	
POP	0.6429* (0.1270)	
INCOME	0.2839 (0.1805)	
KIDS	-0.0609* (0.0230)	
AGE	-0.1652* (0.0555)	
BLACK	0.0003 (0.0088)	-0.0006 (0.0005)
HISPANIC	-0.0227 (0.0231)	0.0001 (0.0014)
R^2	0.34	0.71

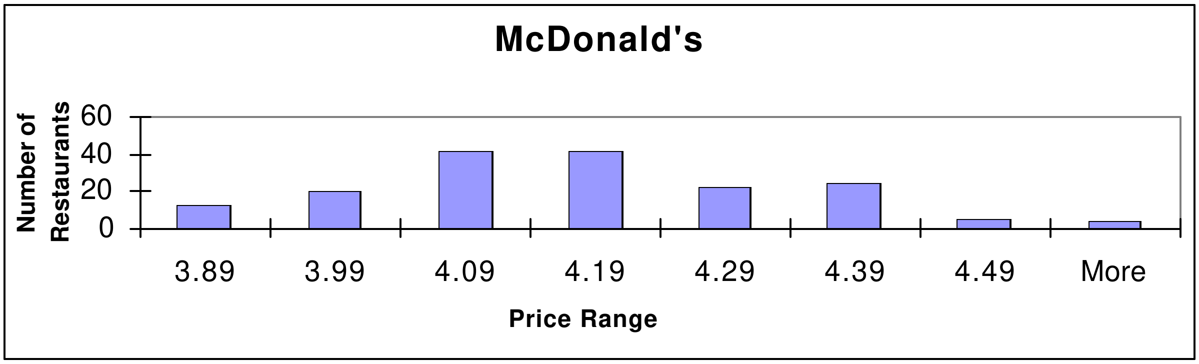
* = statistically significant at the 5% level, ** = 10% level

Table 5.
Estimated Coefficients and Standard Errors, Reduced Form

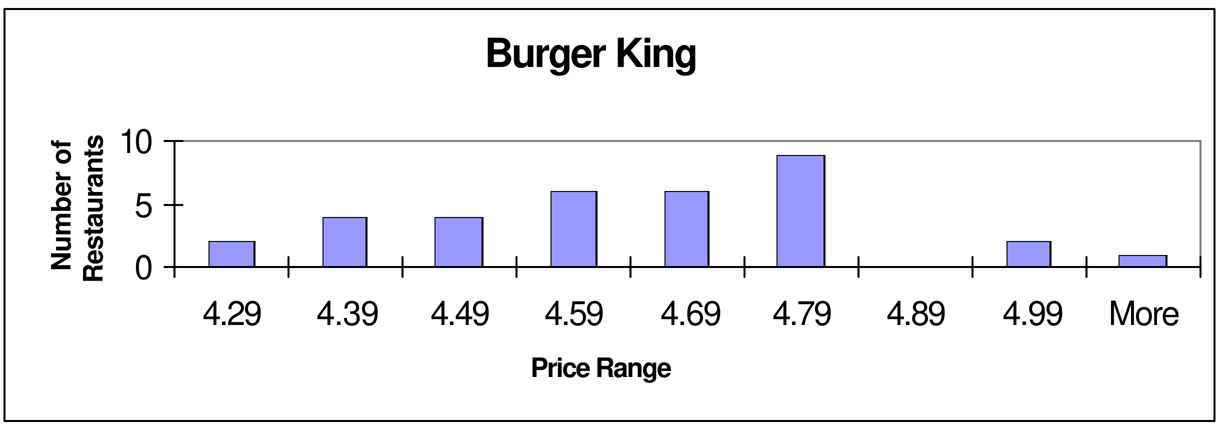
	P
INTERCEPT	4.2657 (0.1323)*
MNT	0.0888 (0.0505)**
VA	0.0027 (0.0505)
PG	0.0844 (0.0529)
WNDY	-0.1987 (0.0612)*
BK	0.4473 (0.0449)*
RURAL	-0.0676 (0.0397)**
CITY	0.1172 (0.0411)*
HOUSE	0.0261 (0.0126)*
POP	-0.0168 (0.0096)**
INCOME	-0.0084 (0.0147)
BLACK	-3.87×10^{-5} (0.0008)
HISPANIC	0.0004 (0.0018)
KIDS	0.0562 (0.1704)
AGE	-0.0031 (0.0045)
R^2	0.719

* = statistically significant at the 5% level, ** = 10% level

Figure 1.
The Observed Dispersion of Fast Food Prices



Most Frequently Observed Price(s): $4.09, $4.19



Most Frequently Observed Price(s): $4.79

Notes:

1) Prices are pre-tax sales prices.
2) The height of the bar indicates the number of retailers charging a price within the indicated range. For example, the height of the first bar in the table corresponding to McDonald's indicates that a dozen of these restaurants were charging $3.89 or less. The height of the second bar illustrates that twenty McDonald's restaurants were charging between $3.90 and $3.99. However, as shown by the height of the third and fourth bars, we most frequently observed prices between $4.00 and $4.19.
3) Notably, a majority of prices were observed at the upper-end of the depicted price ranges. In other words, more prices ended in a nine, such as $3.99, than in any other number like one ($3.91) or two ($3.92).