Testing for imperfect competition at the Fulton fish market

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In this article, I report the results of a study of the prices paid by individual buyers at the Fulton fish market in New York City. In principle, this is a highly competitive market in which there should be no predictable price differences across customers who are equally costly to service. The results indicate that different buyers pay different prices for fish of identical quality. For example, Asian buyers pay 7% less for whiting than do white buyers, a result which is inconsistent with the model of perfect competition.

1. Introduction

■ In this article, I report the results of a study of the prices paid by individual buyers at the Fulton fish market in New York City. In principle, this is a highly competitive market in which there should be no predictable price differences across customers who are equally costly to service. My purpose is to test this elementary "law of one price" in a market in which there are no physical barriers to entry to either buyers or sellers.

Almost all tests for competition have been performed in oligopolistic industries with high entry barriers, in which an initial case study would suggest anticompetitive behavior.[1] These studies use data that have been gathered from public sources such as trade journals, regulatory bodies, or court cases. Most data from court cases exist because there is strong reason to suspect market power. Likewise, trade journals provide information on competitors' actions that may influence behavior. In this article, I test for imperfect competition in a market that should be competitive and use data that were specifically collected for this purpose during a field study of the Fulton market. The set of industries in which imperfect competition has been detected and measured has therefore been expanded to an industry without physical entry barriers in which no public data sources exist.[2]

The results of the study indicate that buyers who are equally costly to service pay different prices for fish of identical quality, which is inconsistent with the model of perfect competition. In particular, I find the surprising result that white salesmen charge white

[1] A notable exception is Ausubel's (1991) study of the credit card market.

[2] See Bresnahan (1989) for a comprehensive survey of empirical studies that measure market power.

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buyers significantly more than they charge Asian buyers for the same type and quality of fish. White buyers pay 7% more for whiting than do Asian buyers.

With the exception of Ayres (1991), price discrimination based on race has received very little attention. Ayres constructed an experiment in the Chicago car market in which test buyers of different races and genders with identical negotiating scripts documented prices offered by various dealers. He finds price discrimination against black and female customers. In contrast, this study finds discrimination against white buyers and in favor of Asian buyers. Ayres' study uses data gathered in hypothetical interviews; in contrast, my study uses data gathered from actual transactions.

Because the owners and employees at the Fulton market are almost all white males and white buyers pay more than Asian buyers, the evidence suggests that third-degree price discrimination is occurring and animus based on race can be ruled out. Economic theory generally associates price discrimination with monopolistic or oligopolistic industries, industries with high search costs, or industries with heterogeneous products. (See Pigou (1932), Robinson (1933), Salop and Stiglitz (1977), and Borenstein (1985).) In this article, I show evidence of price discrimination in an industry that appears to be lacking these characteristics.

In Section 4 of this article, I measure the degree of imperfect competition necessary to support the documented price difference by treating the market comprised of white buyers as separate from the market comprised of Asian buyers. I estimate a conduct parameter for the market by estimating separate inverse demand functions for Asian buyers and white buyers and using the restriction implied by the equivalency of marginal cost between the two groups.

I organized the remainder of this article as follows. Section 2 presents stylized facts about the Fulton fish market and a description of the whiting trade. Section 3 describes the data collection procedure, general summary statistics about the market, and predictable differences in prices received by different customer groups. Section 4 estimates the degree of market power at Fulton Street necessary to sustain the documented price differences. Section 5 interprets the results, and Section 6 concludes the analysis.

2. The Fulton fish market

■ **General description.** The Fulton fish market is located in lower Manhattan near the Brooklyn Bridge. In 1924, the market sold 384 million pounds of fish, 25% of all of the fish sold in the United States (Miller, 1991). The market's importance has declined in recent years because of new methods of supplying fish and competing geographic markets such as Philadelphia and the New Jersey docks. However, Fulton remains the largest market for fresh fish in the United States. Somewhere between 100 and 200 million pounds are currently sold each year (Miller, 1991; Raab, 1991).

The market is located in an open-air structure in which various dealers rent stalls with closed offices at the back of the stalls. Many of the fish dealers are well established and have been in business a long time. Historically, all fish was received at the port of New York City by boat, but currently, all fish is brought in by truck or air from other areas. The market is open from three to nine in the morning on Monday and Thursday and from four to nine on Tuesday, Wednesday, and Friday. (The market is closed on Saturday and Sunday.) About 200 varieties of fish and seafood are sold at the market. There are about 35 dealers in total, and all dealers do not carry all types of fish.

Anyone can purchase fish at the market, but small quantities are not sold. There are no posted prices and each dealer is free to charge a different price to every customer. If a customer wishes to buy a particular quantity of fish, he will ask a seller for the price. The seller will quote a price and the customer will either buy the fish or walk away. Rarely will the customer respond with a price; "bargaining" occurs infrequently and then with

only a very few large customers. Although it is quite easy because of the centralized location for a buyer to ask different sellers for a price, sellers are discrete when naming a price. A particular price is for a particular customer. Most of the customers are repeat buyers, but buyer-seller relationships vary. Some buyers regularly purchase from one seller, and other buyers purchase from various sellers. Most regular buyers follow distinct purchasing patterns based on day of the week.

Fish begin arriving at the market around midnight. Teams of loaders transport the fish from the trucks to the stalls by handtrucks and small motorized pallet trucks. Once the buyers choose their fish, the loaders reload the fish onto the customers' trucks. All transporting of fish at the market is done by the loading teams.

Segments of the market have a history of criminal activities. The *New York Times* quoted law enforcement officers as saying the market has been a Mafia stronghold for 60 years (Raab, 1991). According to investigations, Mafia activity is primarily present in the unloading activities and the parking arrangements of the customers.[3]

□ **The whiting market.** I chose whiting for this study for three reasons. First, more transactions take place in whiting than almost any other fish. Second, whiting do not vary as much in size and quality as other fish. Finally, the dealer from whom the data were collected suggested that the whiting salesman would be the only salesman amenable to having an observer.

Six dealers carry significant quantities of whiting. The minimum quantity of whiting that is sold is one box, approximately 60 pounds, except as favors to regular customers. The whiting is supplied by fishermen's cooperatives, packing houses, and smaller fishing boats in New Jersey, Long Island, and Connecticut each day before the market opens.

The supply arrangements in the market are interesting. The price that a dealer pays a supplier for a particular day's supply of whiting is determined after the sales for that day by the dealer. Each supplier services multiple dealers. According to the dealer from whom I collected the data, dealers compete with each other for fish supplied in the future by the amount they pay the suppliers for fish on a particular day. The dealer stated that he kept 5–15 cents on each pound of whiting sold, but this amount cannot be verified.

The quantity received for a particular day is received in its entirety before the market opens. The quantity that each of the dealers receives is readily observable by all dealers. If one dealer does not receive what he perceives to be enough whiting, another dealer will sell him whiting before the market opens. The price is set not at the time of sale but is determined toward the end of the trading day.

A dealer often has a good idea of the quantity that will be ordered on the following day before the market closes on the previous day, mainly due to weather conditions. Wind and waves increase the cost of catching fish. According to the dealer from whom I collected the data, other determinants of supply are prices in other geographic fish markets, such as Philadelphia and the New Jersey docks, and the price received for whiting relative to the prices received for other fish on days in the recent past.

The whiting market has many of the features of a perfectly competitive market. First, there are no apparent barriers to entry. There are empty stalls at the market, indicating the availability of physical space for new entrants. Whiting is not a fish whose stock is in short supply, and becoming a fishmonger or a fisherman should not require large capital outlays. There are about 35 dealers in total at the fish market; in principle, any of them could sell whiting. Second, the stalls are contiguous, so it is easy for a customer to ask the price from different dealers, and the quantity received by the dealer is readily observable by everyone. Finally, although a dealer may receive boxes of different quality, these differences are easily detected and quantified and no dealer appears to receive on average a higher quality of whiting than does another dealer.

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[3] Both the dealer and the salesman from which the data were collected are white.

3. The data

■ **Data collection.** I used two methods to collect the data. First, one dealer supplied his inventory sheets for the period December 2, 1991–May 8, 1992. All transactions are recorded on the inventory sheets, with information including customer number (a number that uniquely identifies each customer), quantity transacted, price, and whether the trade was cash or charge. Cash trades are recorded in order but not by time of day. Charge trades are not recorded in order. In addition, the total quantity received for the day is documented; 2,868 transactions took place over the time period studied for this particular dealer.

In addition to collecting data from the inventory sheets, I spent 19 days at the market, April 13, 1992–May 8, 1992, recording whiting data by hand. The dealer who supplied the inventory sheets allowed me to record price, amount traded, exact time of trade, observable ethnicity of buyer, and quality of fish for each whiting trade. For each customer that he knew, the salesman would state the general location of the buyer's store or restaurant and the type of establishment. I recorded 489 whiting transactions during this time period.

As should be expected, the transactions collected by hand closely match the transactions on the inventory sheets. Occasionally, through oversight, the hand-collected data would omit a trade that appeared on the inventory sheets. Likewise, the inventory sheets would occasionally omit a transaction that was recorded by hand. When constructing the dataset, the hand-collected data and the inventory sheets were combined for the period April 13–May 8. These data are supplemented by weather data on wind speed and wave height gathered from the boating forecast in the *New York Times*.

To summarize, the data consist of 2,868 transactions for one dealer during the time period December 2, 1991–May 8, 1992 and 489 transactions during the period April 13, 1992–May 8, 1992.

The data were collected from only one dealer primarily because the other dealer who was asked would not agree to participate. I did not pressure additional dealers for fear of upsetting the dealer who originally agreed to my request. In addition, at the beginning of the data collection, I recorded quotes that were turned down, in addition to actual transactions. In hindsight those rejected quotes would be useful, but I discontinued recording them because it was difficult to gather those data in addition to the other information I was collecting. I was not certain that the dealer with whom I was working would supply inventory sheets for the period during which I collected the data until after I had completed my own data collection.

□ **The data and summary statistics.** The following is a detailed description of the data, the aim of which is to provide a better understanding of whiting prices.

Figure 1 is a high-low-close price chart.[4] On the bottom of the graph is a bar chart indicating total sales. The spread of prices throughout the day is very high, and the interday volatility is large. For example, the average price per transaction on Friday, May 1, was $.33/lb., and the average price on Friday, May 8, was $1.75/lb., an increase of almost 600%. The correlation between total sales and average price is $-.32$. Daily supply shocks, primarily caused by weather, are largely responsible for the high volatility in interday price.

The volume of sales does not influence the intraday volatility. Some of the highest volume trading days have quite low intraday volatility.

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[4] The closing price in the graph reflects the price at which the last cash trade took place on a given day (the order of charge trades is not documented). Generally, the last trade that takes place is a cash trade. During the month of hand collection of data, the last trade was a cash trade on 16 out of 19 days.
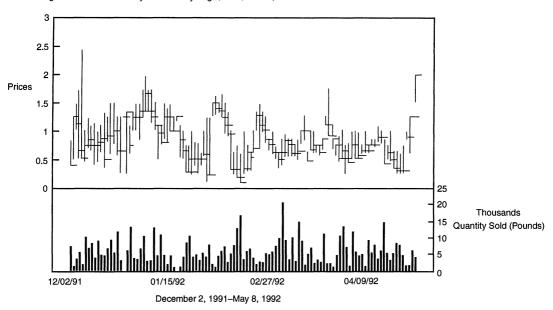
FIGURE 1

Whiting Prices and Quantity Sold: Daily High, Low, Close, and Volume

December 2, 1991–May 8, 1992

   The total quantity received on a particular day does not exactly equal the total quantity sold on a particular day. The correlation between total sales and quantity received is .79. If the quantity received on a particular day is greater than the quantity sold, the whiting is held over and sold the next day. Depending on the quality when it is received, whiting stays sufficiently fresh to sell for at most four days after it is received, although whiting is usually sold the day it is received or sometimes the day after. On 60 out of 111 days, or 54% of the time, the total quantity received exceeded total sales. On those 60 days, the difference averaged 35% of total sales. Overall, the total quantity received exceeded the total quantity sold by 11,237 pounds. Because the total amount sold over the entire period was 702,128 pounds, inventory shrinkage and unrecorded sales were 1.60% of total sales.

   In Table 1, I provide background statistics regarding the way in which days differ from one another on average price per transaction, quantity received, quantity sold, and

TABLE 1   Summary Statistics by Day of the Week

Variables	Monday	Tuesday	Wednesday	Thursday	Friday
Price/transaction	.821	.855	.863	.902	.887
(dollar/pound)	(.304)	(.350)	(.279)	(.311)	(.438)
Average quantity	7420	4443	4890	7454	7980
received (pounds)	(5979)	(4676)	(3503)	(4163)	(5470)
Average quantity	7540	4984	4357	7698	7064
sold (pounds)	(5012)	(4122)	(2834)	(3016)	(4029)
Average quantity	30	65	14	53	126
discarded (pounds)	(91)	(176)	(64)	(166)	(334)

Standard deviations are in parentheses.

quantity discarded. The amount discarded is the amount that was not sold and was literally thrown out. I constructed this table by taking means on each date and then averaging these means by day of the week. I excluded from the statistics the weeks during Christmas and New Year's.

The increase in average price per pound throughout the week is almost monotonic, from \$.82/lb. on Mondays to \$.89/lb. on Fridays. However, the standard deviation in price is much greater on Fridays than on other days. The average total quantity received is lowest on Tuesdays, at 4,443 pounds, but is very similar on Mondays, Thursdays, and Fridays, at 7,420, 7,454, and 7,980 pounds, respectively. Total sales are greatest on Thursdays at 7,698 pounds, second greatest on Mondays, at 7,540 pounds, and smallest on Wednesdays, at 4,357 pounds. The standard deviation of the amount sold is similar to the standard deviation of the amount received. Discarding of fish does not occur regularly and is not significant; the greatest occurrence is on Fridays (six discards), for a total of 2,650 pounds.

The customers are divided into three observable ethnic groups: Asian buyers, black buyers, and white buyers. During the period April 13–May 8, the largest ethnic group of buyers was Asian, purchasing 62% of the total quantity sold (transactions in which ethnic group was identified). The buyers are almost exclusively men. Almost all of the owners and salesmen are white; I did not notice any Asian dealers or salesmen.

The location is recorded by general vicinity of store; for example, areas are Manhattan, Brooklyn, New Brunswick, Princeton. Seventy-eight percent of the total quantity sold, for which location is identified, is to customers in the Manhattan–Brooklyn area. Locations could not be identified for 21% of the total quantity sold. Types of establishments for which whiting is bought are restaurants, stores, shippers, dealers, or fry shops. Fry shops are fast-food restaurants that specialize in fried fish. Some customers will own both a fry shop and a store. During the four weeks I spent at the market, only one buyer, who was white, was pointed out as purchasing for a chain store. Fifty-one percent of the quantity sold was to stores, and 32% was to fry shops. However, 69% of the transactions were with stores and only 18% of the transactions were with fry shops.

Seventy-eight percent of the quantity sold was for cash and 22% was sold on credit. If a customer is a cash customer, he always pays cash. Likewise, if a customer is a charge customer, he always uses credit. The breakdown of cash and credit customers by ethnicity is quite striking. For white buyers, 70% of the transactions took place on credit, but for Asian buyers, only 2% of the transactions took place on credit. This difference may be attributed to the longer period of time that white buyers as a group have been present at the Fulton market. Likewise, white dealers may simply feel more comfortable extending credit to white customers. Credit is not extended for more than one week and appears mostly to be used for convenience of payment. The dealer with whom I worked stated that defaults do occur, although he did not state the incidence.

The quality of whiting varies, in part, because the dealer receives fish from more than one supplier. Based on sight, feel, and smell, I placed the whiting into one of five categories, from very poor quality to very good quality. A value of 1 is assigned to the best quality whiting, and a value of 5 is assigned to the worst quality. I did not find that the quality of whiting sold declined through the day, probably because the temperature outside was near freezing and the fish were well preserved by ice. Appendix A provides a summary table of total quantity sold and the number of observations by customer, quality, and location characteristics.

☐ **Predictable differences in price.** The analysis has so far concentrated on average price per day, but prices during the day varied considerably. The purpose of the following regression is to determine whether customer characteristics or other characteristics specific to a trade can predict the price level within a day. The price of each trade is regressed on

the following variables: time of trade, in which time is broken into three dummy variables, those trades that took place on or before 5:00 A.M. (*TIM1*), trades from 5:00 A.M. through 6:00 A.M. (*TIM2*), and trades from 6:00 A.M. through 7:00 A.M. (*TIM3*); a dummy variable equal to 1 if the location is in Manhattan or Brooklyn (*MLOC*); a dummy variable equal to 1 if the establishment is a store (*STORE*); a dummy variable equal to 1 if the customer is Asian (*ASIAN*); a dummy variable equal to 1 if the customer is black (*BLACK*); average quantity purchased by the customer during the entire time period (*AVQUAN*); a dummy variable equal to 1 if the transaction is in cash (*CASH*); the number of times the customer purchased during the time period (*REG*); and a dummy variable for each date. The dummy date variables are used so that deviations from a daily mean are measured.

In order to explain the differences in prices within a day for the same quality of fish, only medium quality fish are used in the primary regression. In addition, to correct for possible endogeneity, transactions after 7:00 A.M. are not used. As an example of endogeneity, suppose that some customers realize that, if they trade after 7:00 A.M., they may receive a lower price. They then start to hold off on purchases until after 7:00 A.M., causing an expected low price to influence the time at which they trade. The time of trade is then correlated with the error term when price is regressed on the explanatory variables. Endogeneity does not appear to be a factor before 7:00 A.M., as the price decrease is primarily significant after this point. For comparison, all times are used in the regression in column 7 of Table 2. I also estimate a specification of the model that excludes a time correction.

The regression using only medium quality fish and times of trade before 7:00 A.M. is represented in the first column of Table 2. To test robustness of the results and to assess the effect that sample selection has had on the results, the sample is stratified in various ways in columns 2–7.

The Durbin–Watson statistic for the regression in column 1 is 1.85, suggesting that very little autocorrelation is present within days. Including $AVQUAN^2$ and REG^2 has very little effect on the other coefficients, and the coefficients on both of these variables are not significant.

The primary regression (column 1) indicates that ethnicity is the main predictable force that influences the price at which whiting is sold within a day. White buyers expect to pay 6.3 cents per pound more on each transaction than do Asian buyers (approximately 7.0%). This coefficient is significant at the 1% level. None of the other coefficients (except for the date dummies) is significant at less than the 15% level.

In the remaining columns of Table 2, I stratify the data in different ways. Only medium quality fish are used in the regressions in columns 1–5, but all qualities are used in the regression in column 6, with quality corrected by a quality scale of 1–5 (*QUAL*), with 1 representing the highest quality and 5 representing the lowest quality. A linear restriction is placed on the time variable in column 5, and all trades, including those after 7:00 A.M., are included in column 7.

In all of the regressions, the coefficient on the Asian dummy variable is negative, and in all but one of the regressions, the coefficient is significant, mostly at the .01 level. The only regression in which the coefficient is not significant is on customers whose average purchase is over 180 pounds. The lack of a significant price difference for this group of customers is interpreted in Section 4. The coefficient on the dummy variable for black buyers is not significant in any of the regressions. There are few observations on black buyers, which may increase the error.

There does not appear to be a strong decline in price before 7:00 A.M., but the coefficients on the time dummies in column 7 indicate a large decline in price during the last hour of trading, i.e., after 7:00 A.M. Although the coefficients are positive in most of the regressions, the only significant coefficient in the regressions in columns 1–6 is on the *TIM2* dummy variable (the time period from 5:00 to 6:00 A.M.) in the regression in which

TABLE 2   **Determinants of the Price of Whiting**
Dependent Variable: *PRICE*

Variables	(1) Medium Quality Times before 7:00 A.M.	(2) AVQUAN <=180	(3) AVQUAN >180	(4) 6:00–7:00 A.M.	(5) Time	(6) All Qualities	(7) All Times
TIM1	.0074	.0125	.0010	—	—	.0253	.0572*
	(.0138)	(.0197)	(.0311)			(.0135)	(.0148)
TIM2	.0190	.0008	.0217	—	—	.0320**	.0701*
	(.0144)	(.0252)	(.0245)			(.0131)	(.0152)
TIM3	—	—	—	—	—	—	.0406*
							(.0138)
MLOC	−.0190	−.0424	−.0024	−.0048	−.0223	−.0282**	−.0309**
	(.0142)	(.0233)	(.0284)	(.0214)	(.0139)	(.0130)	(.0136)
STORE	.0247	−.0419	.0398	.0069	.0260	.0204	.0129
	(.0194)	(.0343)	(.0356)	(.0262)	(.0194)	(.0205)	(.0169)
ASIAN	−.0635*	−.0707*	−.0220	−.0463**	.0653*	−.0670*	−.0444*
	(.0180)	(.0240)	(.0693)	(.0191)	(.0179)	(.0175)	(.0151)
BLACK	.0004	−.0408	.0739	−.0112	−.0025	−.0145	.0209
	(.0252)	(.0320)	(.0860)	(.0247)	(.0251)	(.0256)	(.0217)
AVQUAN ($\times 10^{-5}$)	−3.97	−20.3	−6.03	−3.16	−3.80	−.440	−4.17
	(2.78)	(24.8)	(6.70)	(3.76)	(2.79)	(2.77)	(2.41)
CASH	.0168	.0341	−.0532	−.0000	.0187	.0072	−.0014
	(.0188)	(.0222)	(.0745)	(.0194)	(.0190)	(.0183)	(.0160)
REG	−.0007	.0037	.0010	−.0013	.0006	.0000	−.0005
	(.0012)	(.0022)	(.0025)	(.0014)	(.0012)	(.0013)	(.0011)
TIME ($\times 10^{-5}$)	—	—	—	−31.1	−3.45	—	—
				(21.5)	(6.12)		
QUAL	—	—	—	—	—	−.0473*	—
						(.0077)	
R^2	.984	.987	.985	.992	.983	.956	.978
Number of observations	131	72	59	54	131	250	165

Standard errors are in parentheses. The coefficients on the date dummies are not reported; in all regressions an *F*-test indicates joint significance at .01.

  * Significant at the .01 level.

** Significant at the .05 level.

all qualities are used. Although Asians do purchase later (the average time of purchase for a white buyer is 5:40 A.M. and the average for an Asian buyer is 6:28 A.M.), it does not appear that differences in purchase times are driving the effect.[5] First, I have corrected for time both by using time dummies in most of the regressions and by trying a linear correction in column 6 of Table 2. Second, when only purchases between 6:00 and 7:00 A.M. are used, the effect remains as shown in column 4. Finally, if the time dummies are excluded from the regressions in column 1, the coefficient on *ASIAN* shows almost no change (it decreases to −.066 using the sample in column 1 and decreases to −.051 using the sample in column 7). The difference in coefficients is far from significant. Because

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    [5] The difference in time of purchase appears to occur because Asians arrive later, not because they shop longer.

exclusion of the time corrections has such a small effect on the ethnicity coefficient, it is very unlikely that differences in time of purchase (or that bias induced by endogeneity between price and time) are causing the differences in price.

The average quantity variable is negative in all regressions but is not significant in any of the regressions. Because there are no apparent cost differences of selling to large quantity versus small quantity customers, one might not expect this variable to be significant. Transportation is always provided by the whiting customer, and one salesman is employed for whiting regardless of the number of customers. Because the cost of a salesman is fixed, time spent negotiating does not appear to be a factor. One possible reason that a negative coefficient might be expected is that sellers are concerned about being left with unsold inventory, although the actual quantities of whiting discarded are very small.

The coefficient on the cash variable is not significant in any of the regressions, and the sign switches back and forth in different regressions. Because charge customers pay the following week, interest effects should be minimal, although one might expect a slight premium for credit purchases due to a risk of default. Excluding the coefficient on cash has very little effect on the Asian coefficient.

In the regression in which all qualities are used, the coefficient on the quality variable is negative and significant, indicating that, within a day, buyers pay less for lower qualities of fish, which would be expected. It is very unlikely that my ability to more finely distinguish between quality categories has increased the Asian-white price difference. First, within a group of boxes of whiting that were quantified as medium quality for the study, Asian buyers appeared as likely as white buyers to be concerned with selecting the highest quality boxes within that group. Second, quality differences within a group on a particular day are very small. Excluding the quality variable when regressing the price on all qualities, as in column 6, only slightly increases the Asian coefficient (to .08).

None of the coefficients on store or regularity is significant. The coefficient on the location variable is negative and significant only in the regressions using all times and qualities, weakly indicating that owners of establishments outside of Manhattan and Brooklyn may pay a slightly higher price.

Because there is a significant difference in price paid by Asian customers and white customers, it is interesting to examine how the two groups differ from one another in other ways. Appendix B provides a breakdown of customer and transaction characteristics by ethnicity.

The results are not presented, but I also interact ethnicity with the other customer-specific variables. White customers located inside Manhattan pay approximately 5 cents less than white customers located outside of Manhattan, and Asian customers who own a store pay about 4 cents more than Asian customers who own a fry shop. In addition, Asian customers who purchase a large amount pay significantly less than Asians who purchase a smaller amount.

The above regressions explain differences in prices within a day for whiting. The dummy variable for Asians places a restriction that the price difference between Asian buyers and white buyers does not vary between days. The restriction can be interpreted as the average difference in prices between Asian buyers and white buyers.

4. Estimating the degree of competition

■   **The empirical model.** Section 3 has shown that the Fulton fish market does not follow the paradigm of perfect competition. Below, I use an econometric model of oligopoly interaction in separable markets to estimate a market parameter that measures the degree to which competition is imperfect.

For price discrimination to persist, arbitrage cannot take place between the two groups. Arbitrage does not appear to be possible at Fulton Street. Buyers do not realize they are

receiving better or worse prices than other buyers. Indeed, I witnessed one argument in which a Korean buyer insisted that Koreans as a group were being discriminated against on price, a belief opposite to the above results. Very little social contact appears to take place between groups of Asian buyers and groups of white buyers. Below, I treat the Asian market as separable from the white market and specify separate inverse demand functions for each group. I also aggregate the transactions by date in order to estimate market inverse elasticities on a particular day for each group.

The inverse demand function on a particular date t for Asian buyers (subscript A) and for white buyers (subscript W) is assumed to be a loglinear function of price:

$$\log P_{At} = \alpha_0 + \alpha_1 \log Q_{At} + \alpha_2 MON_t + \alpha_3 TUES_t + \alpha_4 WED_t + \alpha_5 THUR_t + \epsilon_{dAt} \quad (1)$$

$$\log P_{Wt} = \omega_0 + \omega_1 \log Q_{Wt} + \omega_2 MON_t + \omega_3 TUES_t + \omega_4 WED_t + \omega_5 THUR_t + \epsilon_{dWt}, \quad (2)$$

where P_{At} and P_{Wt} are the average prices recorded on date t for Asian buyers and white buyers, respectively, Q_{At} and Q_{Wt} are the total quantities demanded on date t by Asian buyers and by white buyers, respectively, and ϵ_{dAt} and ϵ_{dWt} are random error terms. MON–$THUR$ are dummy variables for each day of the week. Black buyers are dropped from the sample due to lack of observations.

Because many of the firms have the same supply sources and have outwardly identical firm structure, and because weather is by far the largest factor that shifts marginal cost and weather affects all firms equally, marginal cost is assumed to be identical across firms within a given time period. The marginal cost functions differ across time, and the marginal cost functions for the Asian market (MC_{At}) and the white market (MC_{Wt}) are assumed to differ only by random error terms, ϵ_{cAt} and ϵ_{cWt}.[6] The marginal cost functions on a particular date t are as follows:

$$MC_{At} = MC(q_{iAt} + q_{iWt}, W_t, \gamma, \epsilon_{cAt}) \quad (3)$$

$$MC_{Wt} = MC(q_{iAt} + q_{iWt}, W_t, \gamma, \epsilon_{cWt}), \quad (4)$$

where q_{iAt} and q_{iWt} are the amounts sold by firm i on date t into the white market and the Asian market, respectively, W_t are lagged weather variables, specifically wind and wave heights, and γ are unknown parameters that are identical across firms.

If marginal cost in the two markets is identical across firms and the market demand function takes the above functional form, the market share of each firm will be constant over time whether the firms are perfectly competitive, engage in Cournot competition, or behave monopolistically.

The market demand functions can therefore be rewritten as follows:

$$\log P_{At} = \pi_0 + \alpha_1 \log q_{iAt} + \alpha_2 MON_t + \alpha_3 TUES_t + \alpha_4 WED_t + \alpha_5 THUR_t + \epsilon_{dAt} \quad (5)$$

$$\log P_{Wt} = \gamma_0 + \omega_1 \log q_{iWt} + \omega_2 MON_t + \omega_3 TUES_t + \omega_4 WED_t + \omega_5 THUR_t + \epsilon_{dWt}, \quad (6)$$

where $\pi_0 = \alpha_0 + \alpha_1 \log(1/\beta_{iA})$ and $\gamma_0 = \omega_0 + \omega_1 \log(1/\beta_{iW})$ and where β_{iA} and β_{iW} are the market shares of firm i in the markets in which Asian buyers and white buyers participate, respectively.

Following Porter (1983), in a noncompetitive industry that sells to a market with constant elasticity of demand, price or quantity-setting conduct follows the general supply relations:

$$P_{At}(1 + \Theta_{At} \alpha_1) = MC_{At} \quad (7)$$

$$P_{Wt}(1 + \Theta_{Wt} \omega_1) = MC_{Wt}. \quad (8)$$

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[6] Knetter (1989) used the assumption that an exporter's marginal cost of producing a good is identical across importing countries.

The inverse price elasticities of demand are α_1 and ω_1, as estimated in (5) and (6), and Θ_{jt}, $j = (A,W)$ is an index that measures the competitiveness of firm conduct in each market. If firms price competitively, Θ_{jt} equals zero; if firms maximize joint profits, Θ_{jt} equals one, and if firms produce at Cournot levels, Θ_{jt} equals q_{it}/Q_t, the market share of firm i. Differencing (7) and (8) (assuming MC_{At} and MC_{Wt} differ only by additive error terms) and restricting Θ_{At} and Θ_{Wt} to be identical across time periods, the relationship becomes

$$P_{At}(1 + \Theta_A \alpha_1) = P_{Wt}(1 + \Theta_W \omega_1) + \epsilon_{cWt} - \epsilon_{cAt}. \tag{9}$$

For the estimation, the conduct parameter, Θ, is also restricted to be the same across groups ($\Theta_A = \Theta_W = \Theta$). One convincing argument for identical conduct in the two groups is that the same dealers participate in each market and each group is serviced in the same physical location in the same manner. This restriction is discussed in further detail in Section 5.

Imposing the restriction $\Theta_A = \Theta_W = \Theta$ and dividing (9) through by $(1 + \Theta \alpha_1)$, the relationship to be estimated becomes

$$P_{At} = [(1 + \Theta \omega_1)/(1 + \Theta \alpha_1)] P_{Wt} + \eta_{ct}, \tag{10}$$

where $\eta_{ct} = (\epsilon_{cWt} - \epsilon_{cAt})/(1 + \Theta \alpha_1)$.

The primary purpose behind aggregating the transactions by date rather than using individual transactions data is to estimate a market elasticity on a particular day for each group, not average individual elasticities for groups of buyers. Aggregating by date the quantity sold in each transaction treats walking away and not purchasing in the same manner as it treats purchasing less. However, it may be the case that a customer simply purchased from another dealer or made an *ex ante* decision not to visit the market on a particular day. The day of the week dummies account for predictable *ex ante* decisions not to visit the market based on day of the week; random decisions not to visit the market or to purchase from another dealer should create noise and not affect relationships (5), (6), and (10).[7]

One concern that arises from using the aggregated data for the above analysis is that transaction-specific differences, such as time of purchase and quality of fish, and customer-specific differences, such as whether the purchase was cash or charge and regularity of purchase, can no longer be accounted for. If marginal costs were different for Asian buyers than for white buyers because of transaction- or customer-specific differences, then controls should be included in (10). Customer-specific effects did not significantly influence price, as shown in Table 2; it is unlikely that quality and time differences are significantly affecting differences in marginal costs for the two groups primarily because excluding quality and time from the specifications in Table 2, as described above, has little effect on the Asian coefficient.

☐ **Estimation.** Although ethnicity is observed only for the period April 13–May 8, I was able to increase the sample size for which ethnicity is observed by using customer numbers. By matching customer numbers of those customers who purchased during April 13–May 8 and on which ethnicity was observed with the same customers who purchased

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[7] The individual transactions data could be used to measure the average inverse elasticity of the individual buyers in each group. However, the problem of how to treat customers who did not purchase but walked away becomes acute. If only the data that exist are used, in effect all observations are dropped in which zero quantity was transacted. If zero quantity was transacted because the price was too high, this effect is not accounted for. This effect is taken into account when the data are aggregated by day because of the increase in average daily price of the transactions that actually occurred.

before April 13, I constructed a new sample of repeat buyers, defined by those customers who purchased before April 13 and who purchased during the period April 13–May 8. The characteristics of the sample of repeat buyers differ little from the characteristics of all buyers. In total, there are 171 different customers, 1,775 observations, and 493,576 pounds sold to repeat customers during this period.

Because quantity sold and price are endogenous, instruments are needed for the variables quantity sold to Asian buyers and quantity sold to white buyers. Eight instruments are used for each of the quantities sold: four measurements of weather from the Atlantic ocean near the coast of Long Island and dummy variables for each day of the week. The holiday period, December 16–January 3, is excluded from the sample, and December 3 is dropped because there are no observations on white buyers. The regression of the quantity variables on the instruments is presented in Appendix C.

To exploit the correlation in the error structure resulting from simultaneous shocks to q_{iA} and q_{iW}, I use an iterative three-stage least-squares estimation procedure. I correct for autocorrelation in the error structure using the Cochrane–Orcutt method. As a comparison, the results from an uncorrected three-stage least-squares and a two-stage least-squares estimation procedure are also presented. The estimates of the demand equations are presented in Table 3, and the estimates of the conduct parameter, Θ, are presented in Table 4. The results using the three methods are similar. As might be expected, the Cochrane–Orcutt method corrects for autocorrelation in the errors, and the iterative 3SLS procedure decreases the errors relative to 2SLS (the t-statistics decrease from -2.83 and -2.50 on $\log q_A$ and $\log q_W$, respectively, to -3.14 and -2.56 using iterative 3SLS).

TABLE 3 Estimates of the Demand Function for Whiting
Dependent Variables: Log of Average Daily Price for Asian Buyers ($\log P_A$)
and Log of Average Daily Price for White Buyers ($\log P_W$)

	Error Corrected Iterative 3SLS		Iterative 3SLS		2SLS	
	$\log P_A$	$\log P_W$	$\log P_A$	$\log P_W$	$\log P_A$	$\log P_W$
$\log q_{iA}$	−.598*	—	−.611*	—	−.762*	—
	(.213)		(.195)		(.270)	
$\log q_{iW}$	—	−.753**	—	−.717**	—	−.972**
		(.361)		(.280)		(.391)
MON	−.222	.290	−.224	.202	−.465*	.132
	(.202)	(.215)	(.200)	(.205)	(.265)	(.267)
TUES	−.363	−.406	−.440***	−.464***	−.628***	−.679***
	(.220)	(.288)	(.228)	(.277)	(.305)	(.373)
WED	.001	−.020	−.115	−.231	−.365**	−.487
	(.168)	(.223)	(.190)	(.259)	(.252)	(.348)
THURS	.099	.670**	.037	.445***	−.073	.504
	(.156)	(.324)	(.169)	(.230)	(.221)	(.305)
Const.	3.144**	3.516***	4.473*	4.864**	5.761*	6.751*
	(1.237)	(1.803)	(1.552)	(2.020)	(2.146)	(2.810)
Durbin–Watson	1.83	1.92	1.30	1.29	1.43	1.42
Number of observations	96	96	97	97	97	97

Standard errors are in parentheses.
   * Significant at the .01 level.
  ** Significant at the .05 level.
 *** Significant at the .10 level.

TABLE 4	Estimates of the Conduct Parameter (Θ)		
	Error Corrected Iterated 3SLS	Iterated 3SLS	2SLS
Θ	.388	.518	.291
	(.640)	(.825)	(.500)

Standard errors are in parentheses.

The inverse elasticity estimates in Tables 3 and 4 are quite reasonable and within one standard deviation of each other using different estimation methods. The inverse elasticity estimates are negative and less than one in absolute value. Thus, as would be expected with profit maximization, the marginal revenue associated with the industry demand curve is positive. The inverse elasticity estimate for white buyers is larger in absolute value than the estimate for Asian buyers, although the difference in the inverse elasticities is not significant. The estimates of the conduct parameter are all between zero and one as would be expected, although the standard errors are quite large. A t-test cannot reject either the hypothesis that the conduct parameter has value zero or the hypothesis of perfect collusion (i.e., that the conduct parameter has value one).

5. Interpretation

■   I present strong evidence in this article that the law of one price does not hold at the Fulton market and that price discrimination is present. The reason behind the price discrimination is less clear. The results of the above estimation of the conduct parameter can be interpreted in several ways.

First, one interpretation of the point estimates of the inverse elasticities suggests a higher elasticity for Asian buyers than for white buyers, which is consistent with discrimination resulting from optimal pricing on the part of the firm. In addition, the estimates of the conduct parameter suggest the presence of a degree of competition that corresponds to two or three firm symmetric Cournot behavior, depending on which estimation method is used. The size of the conduct parameter indicates that some collusive behavior is occurring, given there are six firms with over 30 potential entrants.[8] The lack of significance of the estimates may be attributed to small sample size or noise resulting from aggregation over the day.

Another interpretation of the above estimates is that there really is no difference in the inverse elasticities of the two groups, and the difference in pricing results from different conduct on the part of the firms toward the two groups. Many different values for Θ_A and Θ_W would be consistent with this assumption. For example, it could be the case that firms are behaving competitively toward Asian buyers and competing as in a Cournot model with six symmetric firms toward white buyers. Alternatively, firms could be behaving perfectly collusively toward white buyers and only slightly less than perfectly collusively toward Asian buyers.[9]

Although the same dealers participate in each market and each group is serviced in the same physical location in the same manner, it is perhaps possible that differences in conduct toward the two groups exist. Asian buyers appear to be more organized than white

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[8] The six firms at the market appeared to sell approximately equal amounts; the Herfindahl index would therefore be one-sixth.

[9] If Θ_W is restricted to equal one and the inverse elasticities for the two groups, α_1 and ω_1, are restricted to be the same, the error corrected iterative 3SLS estimate for Θ_A is .949, with standard error .047, and the inverse elasticity estimate ($\alpha_1 = \omega_1$) is $-.625$, with standard error .210. If Θ_A is restricted to equal zero, then Θ_W is estimated to be .124, with standard error .049.

buyers. The Korean buyers have a retailers' organization that appears to be quite active. In the past, the association organized a boycott of one of the dealers because he was allegedly shortchanging the pounds of fish included in a box. The dealers at Fulton Street may recognize that this organized group may have more options, one of which is purchasing as a group from the wholesalers or fishing boats that supply the dealers at Fulton Street. These options may force a competitive price. Another explanation for the difference in conduct parameters is that Asians as a group are relatively recent entrants at Fulton Street. Standards for conduct between dealers in the two groups have thus evolved at different times and over different time periods.

The lack of overt barriers to entry does not necessarily call into question the above two arguments. Restricted entry may have developed given the history of fraudulent operations. In 1990, evidence was cited that some wholesalers defrauded fish companies from about $6 million in the last few years. It was also asserted that "the strong-arm tactics of some companies at the market discouraged suppliers from sending fish to New York"(Raab, 1990a). According to Frank Wohl, a federal administrator appointed to monitor the market, "extortion and violence at the market in lower Manhattan had led to higher retail prices for fish in the city" (Raab, 1990b). Because a large amount of fish is supplied to the dealer on credit, these allegations understandably encourage suppliers to be unwilling to do business with new legitimate dealers. Even if new dealers were willing to pay cash up front for the fish received, the alleged presence of the Mafia and the poor reputation of the market would discourage entry.

If fraudulent operations have created barriers to entry and collusion is present, it is certainly possible that tacit, rather than overt, collusion is driving the price discrimination. The firms at the Fulton market order quantities to sell and choose prices, repeatedly, every working day of the year and have, in some cases, been interacting for over 50 years.

The price differentials could also be arising from a model of equilibrium price dispersion similar to Salop and Stiglitz (1977). If Asians are more willing to spend time searching for a lower price and sellers randomly vary their prices, Asians on average will pay a lower price. Although I was not able to collect prices charged by other dealers at the Fulton market, Kirman and Vignes (1991) found evidence of price dispersion at the Marseilles fish market.

The primary argument against price dispersion as the cause of the difference is that the market is very centralized and search costs are very low. However, whereas the average white buyer would save about $9.00 per transaction by searching and may not find it worthwhile to search, white buyers who purchase large quantities may find it worthwhile to search. This explanation is consistent with the result that a difference in price for Asian buyers and white buyers is not significant for the sample containing only large quantities.

6. Conclusion

■ Contrary to the predictions of the standard model of perfect competition, the law of one price does not hold at the Fulton market. White buyers pay higher prices than Asian buyers for the same type and quality of fish. Point estimates of a conduct parameter suggest the presence of some collusive behavior. Alternatively, the differences in price could be the result of different conduct in the two markets or equilibrium price dispersion.

Appendix A

Summary Statistics of Customer Characteristics: April 13, 1992–May 8, 1992

	Transactions	Percent of Total Observed Transactions	Quantity Purchased (Pounds)	Percent of Total Observed Quantity
Ethnicity				
Asian	242	51.49	66,430	61.64
Black	36	7.66	12,565	11.66
White	192	40.85	28,770	26.70
Total observed for ethnicity	470	100.00	107,765	100.00
Location				
Manhattan–Brooklyn	290	79.67	68,885	78.27
Other	74	20.33	19,120	21.73
Total observed for location	364	100.00	88,005	100.00
Establishment				
Store (only)	309	68.82	53,810	51.03
Fry shop (only)	81	18.04	33,355	31.63
Store and fry shop	40	8.91	10,000	9.48
Fulton dealer	10	2.23	5,660	5.37
Other	9	2.01	2,620	2.48
Total observed for establishment	449	100.00	105,445	100.00
Payment				
Cash	335	69.65	85,025	77.88
Credit	146	30.35	24,145	22.12
Total observed payment	481	100.00	109,170	100.00
Quality				
Very good	103	22.34	23,255	21.77
Good	60	13.01	11,590	10.85
Medium	237	51.41	56,090	52.51
Poor	34	7.37	9,820	9.19
Very poor	27	5.86	6,070	5.68
Total observed for quality	461	100.00	106,845	100.00

Total number of observations: 489.
Total quantity sold: 110,970 pounds.
Number of different customers: 209.

Appendix B

Number of Observations by Ethnicity: April 13, 1992–May 8, 1992

	Asians	Blacks	Whites
Very good quality	47 (20%)	5 (14%)	48 (26%)
Good quality	25 (11%)	4 (11%)	30 (17%)
Medium quality	122 (52%)	19 (53%)	94 (52%)
Poor quality	24 (10%)	2 (5%)	6 (3%)
Very poor quality	18 (8%)	6 (17%)	3 (2%)
Located in Manhattan or Brooklyn	145 (79%)	28 (90%)	118 (79%)
Located outside Manhattan or Brooklyn	39 (21%)	3 (10%)	32 (21%)
Store	139 (71%)	9 (28%)	162 (99%)
Fry shop	56 (29%)	23 (72%)	1 (1%)
Cash	239 (98%)	33 (92%)	57 (30%)
Credit	4 (2%)	3 (8%)	135 (70%)
Number of customers	110	18	66
Number of transactions	243	36	192
Average time of trade (minutes)	6:28	6:16	5:40
Average price per trade (dollars)	.73	.64	.80

Appendix C

**Reduced Form Determinants of Quantity Sold
Independent Variables: log Quantity Sold to Asian
Buyers and log Quantity Sold to White Buyers**

Variables	log Quantity Sold to Asian Buyers	log Quantity Sold to White Buyers
log *WIND*	.088	−.224
	(.305)	(.281)
log *LAGWIND*	−.576	−.141
	(.380)	(.350)
log *WAVE*	−.432	−.333
	(.320)	(.295)
log *LAGWAVE*	−.082	−.218
	(.326)	(.300)
MON	−.489	.146
	(.280)	(.258)
TUES	−.688**	−.648**
	(.278)	(.256)
WED	−.446**	−.584**
	(.270)	(.249)
THURS	−.210	.395
	(.268)	(.246)
const	10.219*	8.996*
	(1.075)	(.989)
R^2	.18	.29
Durbin–Watson	1.74	1.74
Number of observations	97	97

WAVE = maximum of the past two days' average wave heights.
LAGWAVE = maximum of the average wave heights three and four
days prior. *WIND* = minimum of the past two days' minimum wind
speeds. *LAGWIND* = maximum wind speed three days prior.
  Standard errors are in parentheses.
  * Significant at the .01 level.
  ** Significant at the .05 level.

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