The Effects of Refineries on Neighborhood Property Values

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Abstract. **Capitalization of negative neighborhood externalities may be affected over time by household sorting, events that attain public notoriety and the relative proximity of adjacent parcels to the externality. Using a 1,999-observation database spanning thirteen years all three of these issues are empirically investigated for two petrochemical refineries. As expected, evidence of sorting, short-term event effects and nearby proximity are all found to be contributors to capitalization. The extent of nearby buffering land areas also appears to contribute to reducing capitalization.**

Introduction

While the presence of a petroleum refinery may have positive impacts on a community as a whole, few would argue that the refinery represents an appealing neighbor for residences in close proximity. Indeed, there are several reasons why refineries may be perceived as producing negative externalities. To a certain extent, they are offensive to the senses; their air emissions raise the specter of health risks, and may also impose greater maintenance expense on neighbors; and there is the danger of explosions, which have the potential to severely damage property in close proximity. The existence of these negative perceptions is exemplified by recent legal actions and activity in the real estate markets, which suggest that property values surrounding petroleum refineries may be negatively impacted.[1,2,3]

There are approximately 300 refineries operating in the United States, and by far the largest concentrations of these are located in California, Louisiana and Texas—41, 30 and 56 respectively).[4] While many of these refineries are sited in remote locations, a substantial number are positioned near populated areas (considering just Louisiana and Texas, metropolitan areas affected include New Orleans, Baton Rouge, Shreveport, Lake Charles, Houston, Port Arthur, Corpus Christi, Beaumont, and Brownsville). Obviously, the number of properties nationwide that are located in proximity to refineries is very large. The questions still remain whether the value of property close to a refinery is depressed relative to those further away; and, if such an effect does exist, has it changed over time.

Subdivisions that developed near established refineries presumably would have benefitted from a lower land cost at the time of their development (the owner before the refinery was built presumably would have suffered a loss). If the impact of the

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refinery has remained constant over time, then the purchasers of the homes would not necessarily be damaged by the refinery, even if subsequent sale prices were lower than comparable homes in non-impacted neighborhoods. However, properties developed prior to the increased environmental awareness may have had their value depressed by the combination of their location and the increased public awareness of the impacts of environmental problems.

Theoretical Framework

The problem is essentially one of neighborhood preference and it can be viewed in terms of residential location theory. Using the two-dimensional model presented by Straszheim (1987), each location can be considered as a point in a rectangular coordinate system defined by its X and Y coordinates and characterized by a vector of neighborhood attributes. Some of the attributes may be attractive and some may be negative in nature, with the perception of "good" and "bad" varying among individuals. The consumer tries to maximize utility by choosing a combination of composite goods, housing characteristics, quantity of land, and locational attributes that maximizes utility, subject to a budget constraint that includes the price of the housing. The degree to which a particular attribute is capitalized into the property value depends upon several factors. Starrett (1981) notes two conditions for full capitalization: (1) There is a perceptible differential between the impact on locations close to the externality and those located at a distant boundary; and (2) residents do not sort themselves according to relative preference regarding proximity to the externality. With regard to a refinery, the first of these conditions implies that the refinery must be perceived as a negative influence, and also that this negative influence is not uniform throughout the area in question. The second condition recognizes that the market price will be set by the marginal buyer, who is probably more optimistic than many others in the community, and if buyers exist who perceive the refineries more favorably, negative capitalization of the refineries will be diminished or eliminated.

It is reasonable to expect that the degree to which a neighboring property is affected by the negative influences of a refinery diminishes as the distance from the refinery increases, although the relationship may be stepped or nonlinear in nature. As typical in the economic literature dealing with externalities of various types, this assumption can be used to establish "distance" as a proxy for the net effect of the refinery, and hedonic regression techniques[5] can be employed to determine the impact of this distance variable on price. The data set for the hedonic regression usually includes the sale price and variables relating housing and neighborhood characteristics, as well as the distance variable. The estimated implicit price of distance from a refinery is the partial derivative of price with respect to distance. The effective use of hedonic regressions is enhanced when there is a large number of sale transactions suitable for the database, a condition that favors its use in densely populated areas. The technique is also limited to detecting only the net effect of all positive and negative influences, since the attractiveness of each site depends on the vector of all neighborhood attributes. However, the potential does exist to detect and estimate the net proximity effect, and to also detect changes in this net effect over time.

Economic Literature

The theoretical relationship between environmental factors and the value of real estate has been investigated in the economic literature since 1968 for various types of externalities. Typically, these studies are empirical in nature and utilize hedonic methods to try to identify an implicit price for environmental quality. The earliest examples in the economic literature focused on the air quality in a particular locality and attempted to establish the "benefit" derived from air quality regulations. Notable works in this area include Ridker and Henning (1967), Anderson (1971), Rosen (1974), and Freeman (1974).

Since 1980, the literature has primarily addressed the effect of a particular environmental site on the value of the surrounding real estate. A substantial number of these papers have examined the effects of landfills on surrounding properties. A recent work on landfills was presented by Bleich, Findlay and Phillips (1991), who found a well-designed landfill with adequate buffer zones had no significant impact on the proximity area's property values. Some other types of environmental sites examined in these studies include nuclear power plants and sites contaminated with hazardous waste of various types. Nelson (1981) studies the properties around the Three Mile Island nuclear facility, and found the "event" had no significant impact on value, a result he attributed to the anticipated cleanup and the perception of safety. Beron (1991) investigated the effects of publicized leaks from a uranium processing plant. She found a significant value discount for properties in close proximity, but did not detect a significant change in this effect which could be attributed to the publicized event. Kinnard (1991) analyzed neighborhoods contaminated with radioactive radium and found proximity effects fairly localized and temporary in nature. As a final example, Kohlhase (1991) pooled all of the residential properties in the Houston area to examine changing value patterns relative to the ten Superfund sites in Harris County. She concluded that the EPA classification of sites as "superfund sites" created a premium value for properties more distant from the contaminated sites.

All of these previous hedonic studies regarding specific environmental sites used one of two basic empirical approaches. Many of the studies on landfills, as well as the Kohlhase paper, used the distance from the environmental hazard as a hedonic variable (Kohlhase used a quadratic specification of distance). The other studies, including those by Bleich et al., Beron, Kinnard, and Nelson, all used a comparison between areas, often including an unaffected control area. In these area comparisons, dummy variables were used to define the area in which a particular observation was located.

It is interesting to note that, even in the case of serious environmental problems, any negative impacts on surrounding properties were generally localized, and detected effects dissipated quickly after problems were solved. It is also noteworthy to recognize that the changing pattern of property values noted by Kohlhase might be the result of a general increase in environmental awareness, and given the probable collinear relationship between the Superfund sites and operating petrochemical sites, the premium demanded for more distant properties may suggest an emerging concern regarding proximity to the industrial areas in general.

In a related work, Colwell (1990) used hedonic techniques to investigate properties located within 400 feet of electrical transmission lines. He found a significant proximity effect that dissipated quickly as the distance increased. He also noted the impact decreased over time, and he conjectured this diminishing impact may have been due to "screening" provided by growing trees.

Empirical Study

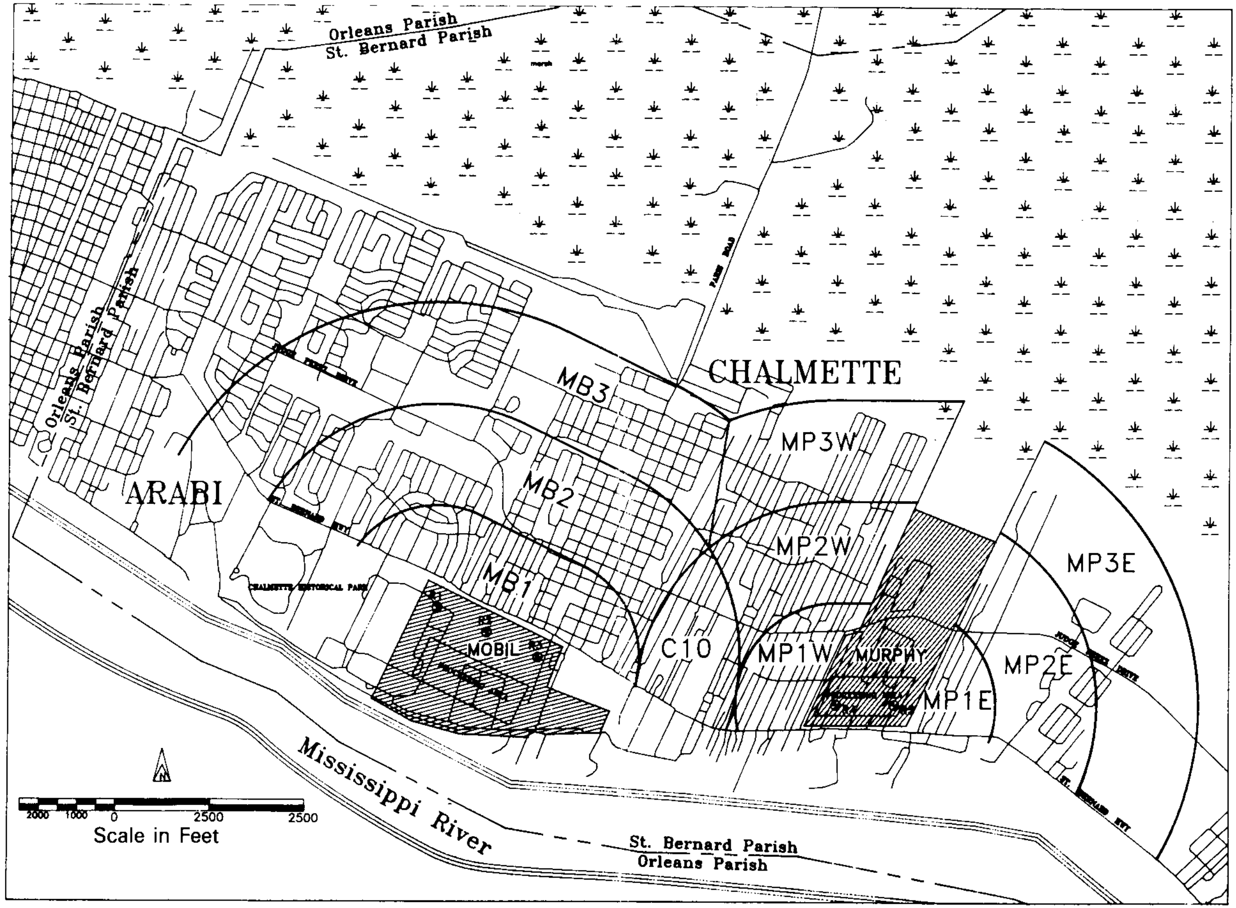
Geographic and Demographic Information

This paper summarizes a hedonic study involving St. Bernard Parish, which is located immediately below New Orleans on the east bank of the Mississippi River.[6] This parish provides an interesting subject for such a study for several reasons. There are two refineries spaced 1.5 miles apart that are located in the midst of the parish's most populated area (see Exhibit 1). The 1990 Census indicates the parish population is 66,631, and as noted below, there has been a sufficiently large number of transactions to allow an empirical study. The parish is completely isolated from the rest of the New Orleans metropolitan area by intracoastal canals and the Mississippi River, and there is a total of only three bridges providing access into New Orleans. Because residential areas are screened from the River by several factors (a levee, batture areas, and industrial sites), a scenic view of the River is not a neighborhood factor. Since nearly 70% of St. Bernard's labor force works in New Orleans, commuting times do not vary appreciably across the parish, and therefore do not significantly affect this research (in Model 1 described below, which pooled data from all areas of the parish, distance to the main bridge into New Orleans was included as a neighborhood variable). All public services are provided on a parish-wide basis, which further simplifies the analysis.

One of the refineries is owned by Mobil Oil Corporation, and the other is owned by Murphy Oil Company. The Mobil refinery is the larger of the two refineries in terms of processing equipment and production volume. The processing equipment in the Mobil plant is located about .15 of a mile from the fence line on St. Bernard Highway. St. Bernard Highway, with its four traffic lanes, neutral ground, and strip of commercial properties, provides an additional buffer between the Mobil plant and the closest residential properties. The processing area of the Murphy refinery is not as isolated from residential properties as that of Mobil. Residential neighborhoods parallel both sides of the refinery property, and on the west side, homes on the nearest street are situated about 100 yards from processing equipment. Since most of the homes in the area near the refinery front on the streets running parallel with the refinery, either the front or rear of each house faces the refinery.

The negative effects of refineries involve varying levels of uncertainty, and economic theory suggests that the market should capitalize this uncertainty into prevailing property values based on the current perceptions of the risks. Negative changes in public perception caused by publicized "environmental" events or other factors are expected to cause reductions in the equilibrium prices of a localized real estate market. As the perception of danger increases, properties in areas perceived to be affected are expected to decline in value. This paper recognizes two environmental events that potentially could have caused such a shift in public perceptions: (1) Published studies suggesting a statistical link between industrial pollution in South Louisiana and the

Exhibit 1
Model 1: Proximity Areas, Mobil and Murphy Refinery



Source: Flower 1993

high incidence of cancer in the region prompted considerable publicity during 1982 (these studies prompted the nickname "Cancer Alley" for the parishes adjoining the Mississippi River from Baton Rouge to the river delta); and (2) an explosion of a storage tank at the Tenneco (now Mobil) Refinery in September 1983.

Assuming that refineries are perceived as a negative influence, it is rational to expect that distance from the refinery should be positively valued in all years, and that a change in environmental awareness may cause the premium paid for distance to increase. Because the study area contains two refineries, and presumably both would have a proximity effect, the empirical model must allow for separate impacts from both refineries in various time periods. The study is complicated by the relatively short distance of 1.5 miles separating the two refineries, since there potentially may be an area of confluence between the two refineries that is more severely impacted than an area similarly located with respect to only one refinery.

Spatial Models

As noted previously, the literature that has applied the hedonic method to study the effects of environmental sites has used one of two basic approaches: (1) a specification with a distance variable included as a proxy for the environmental effect; and (2) a comparison of areas in close proximity with more distant areas, often including a control area. This study utilized both of these methods. Model 1 was structured using dummy variables to define segmented areas based on increasing minimum distance from selected reference points in the processing area of each of the two refineries (see Exhibit 1 for reference points). A separate area was defined in Model 1 for the area of confluence. Model 2 was structured using the actual distance from the refinery as the environmental variable.

The general model used for the hedonic study of the effects of the refineries on surrounding property values is noted below:

$$P_t = h\,(H_t,\ N_t,\ E_t)\ ,$$

where

P_t=sales prices for single-family dwellings at time t;
H_t=vector of housing characteristics at time t;
N_t=vector of neighborhood attributes at time t;
E_t=vector of environmental effects at time t.

Data

Both models used a data set of actual transactions obtained from two similar sources: (1) a database maintained by the University of New Orleans Real Estate Market Data Center, which is based on transactions reported by appraisers; (2) the Multiple Listing Service published by the Jefferson Parish Board of Realtors. For each site, information was available on the actual price, dimensions of the lot, and housing characteristics that previous studies have typically shown to be significant.

The following information was recorded for each site: street address; year of sale; month of sale; sale price; lot front; lot depth; age of the house; number of bedrooms; number of bathrooms; number of half-baths; living area; type of heating; type of cooling; type and number of parking accommodations; a subjective rating of the condition; the presence of a fireplace; the presence of a porch or patio; and the presence of a built-in swimming pool. The address was used to establish a geo-code of the location. The year of sale was used to create year dummy variables, and to establish subsets of data. Variables actually used to describe the housing characteristics included the age; the number of bedrooms; the number of baths; the number of half-baths; square feet of living area; a condition rating; the number of fireplaces; and dummy variables created to denote the presence of central air conditioning, central heating, single-car or two-car garage, a patio, and a swimming pool.

A total of 1,999 observations were included in the data set, which includes transactions for all of St. Bernard Parish during the period 1979–1991. Since identifying changes in the effect of the refineries on property values over time was a primary goal of the study, a price index was constructed using a hedonic regression on transactions in a control area (properties in St. Bernard more than 1.5 miles from the refineries), and the index developed was used to adjust the sale prices for the data set.[7]

It was previously noted that the buffer zones separating the processing area of the Mobil refinery from neighborhoods is substantially greater than that of the Murphy refinery, particularly on the west side of the Murphy refinery. Interviews with local appraisers suggested the existence of several other factors that may impact the relative values of the proximity areas in question.[8] They indicated that the area closest to the Mobil refinery has traditionally been viewed as a prestigious and desirable neighborhood,[9] and that the prevalence of smaller homes in that area minimizes the influence of down cycles in the market. They also noted two positive factors impacting the area between 1.0 and 1.5 miles northwest of the Murphy refinery: (1) the presence of the parish's best private elementary school; and (2) the emergence of prestigious new developments on the only available vacant land within the limits of Chalmette. They described several negative factors in the area abutting the east side of the Murphy refinery, including the prevalence of multifamily units and a trailer park near the east side of the Murphy refinery, the below-normal maintenance of properties in the area, and a low number of single-family transactions in periods after 1984. Lastly, they noted the emergence since 1984 of a prestigious subdivision approximately 1.25 miles east of the Murphy refinery. While all the factors cited above are considered relevant, the collinear nature of these factors with respect to the distance variables used in the models that follow precluded accounting for them explicitly in the empirical study. However, their possible influence on the results was recognized and acknowledged in the following discussion.

Model Specification

Cassel and Mendelsohn (1985) noted that when specifying a hedonic model, a trade-off is generally involved between achieving the "best fit" with the data and obtaining a result that is easily interpreted. Further, they recognize that the best-fit specification may not be one that best explains the effect of any specific variable of interest. As suggested by Halvorsen and Pollakowski (1978), and Bender et al. (1980), Box-Cox transformations of either the dependent variable, or both dependent and independent variable, can be used to estimate a best-fit specification. The best-fit transformations of the independent variables, which usually involve interaction terms, are particularly difficult to interpret in a hedonic model. Even for transformations limited to the dependent variable, unless the results identified a linear or natural log form as best, the coefficient estimated for the environmental variables would be awkward to interpret and analyze in terms of the transformed dependent variable. This study followed the bulk of the previously noted literature and confined the forms estimated to the linear and logarithmic specification. Given the presence of independent dummy variables, a Box-Cox transformation of the dependent variable was employed solely to gain insight regarding any best-fit preference for either the linear or logarithmic forms for the dependent variable only. A Box-Cox maximum likelihood analysis of Model 1 estimated λ^* as .50, where a $\lambda^*=0$ implies a natural logarithmic form is best, and $\lambda^*=1$ indicates a linear specification. The λ^* value of .5 implies a square root transformation of the dependent variable "price" results in the "best fit," but as noted above, the concept of the square root of price is certainly not as easily interpreted as the more commonly encountered linear or semi-log forms. Since the estimated λ^* did not suggest a preference for either the linear or semi-log forms, both specifications were estimated for all the various models considered, and results using all the specifications were checked for consistency.[10] Since the linear form offers the most direct interpretation, it was the specification generally reported. However, the logarithmic form of price was employed in the regressions used to construct the price index and also, the regressions used to estimate the marginal price of distance (see Model 2 result). With regard to the independent variables, Model 2 considers a variety of logical specifications for the environmental variable in an attempt to identify the best specification.

Model 1

In Model 1, ten proximity areas were identified based on distances calculated from selected reference points in the refineries (the reference points (R1–R5), and the Model 1 areas are indicated in Exhibit 1). A Model 1 dummy variable was defined for each of the areas, and these variables were assigned a value of 1 if the site was located within the specified range, and 0 if it was not. C10 designated the area of confluence located between five- and ten-tenths of a mile from the two refineries. MB1, MB2 and MB3 were the Mobil proximity areas listed in the order of increasing range in increments of .5 miles. MP1W, MP2W and MP3W denoted similar increments on the west side of the Murphy refinery, and MP1E, MP2E and MP3E were the proximity areas east of the Murphy refinery.

This model pools the observations in the specified proximity areas with those not included in any of these areas. For any chosen time period, the coefficients of the proximity areas estimated by a hedonic regression of the pooled data can be interpreted as the premium or discount required for locating in a proximity area, as compared to the average of those properties not in any proximity area.

Unfortunately, transaction data is not available prior to 1979, so the data available

Exhibit 2
Model 1 Results, Time Periods T1, T2 and T3

	Model 1, T1 1979–1981 Adj. *R*-squared = .707 233 Cases			Model 1, T2 1982–1983 Adj. *R*-squared = .753 262 Cases			Model 1, T3 1984–1985 Adj. *R*-squared = .693 279 Cases		
Area	***B***	**S.Err. *B***	***p*-level**	***B***	**S.Err. *B***	***p*-level**	***B***	**S.Err. *B***	***p*-level**
MB1	3871	2769	.164	1133	3381	.737	2925	3402	.391
MB2	−112	2096	.957	6098	3225	.060	−1723	2487	.489
MB3	1977	2585	.445	3723	2576	.149	−3763	3128	.230
MB1W	3043	2429	.211	6174	2165	.004	−2941	3552	.408
MP2W	3240	2214	.145	5527	2254	.015	6620	3093	.033
C10	−185	3591	.959	2223	2199	.313	−989	4210	.697
MP3W	669	2283	.769	7905	2417	.001	4980	3061	.746
MP1E	−4667	3157	.141	−3372	1996	.092	1855	6327	.431
MP2E	584	2197	.791	2824	2693	.295	6539	3886	.633
MP3E	−1339	3693	.717	4471	3195	.163	6421	2820	.021

Source: Flower (1993)

prior to either environmental event is limited. The time subsets considered in the study are as follows: 1979–1981; 1982–1983; 1984–1985; 1979–1983; 1984–1988; and 1988–1991. The first time period precedes both the "Cancer Alley" publicity and the tank explosion, while the 1982–1983 subset actually encompasses the period when the bulk of the negative publicity occurred. The 1984–1985 data represents the short-term post-event period. The regression results for these first three time subsets are summarized in Exhibit 2. The last three subsets provide a more long-term view of the changing proximity values, with 1979–1983 encompassing the events, and the latter two periods separating the post-event period. The regression results for these last three subsets are recapped in Exhibit 3.[11,12]

As noted above, the coefficient on the area dummy variable was interpreted as a value premium or discount relative to those properties in the control area. Therefore, a direct comparison of respective coefficients in different time segments was not justified, since there was no reason to believe the control area values remained constant. However, within a given time segment, a significant difference in the coefficients of the dummy variables for areas of varying proximity was indicative of a proximity effect. Further, a significant change over time in the relationship between two areas was evidence of a temporal change in the proximity effect.

The results reported in Exhibit 2 and Exhibit 3 were unexpected in several ways. It was hypothesized that the value of the areas in closest proximity to the refineries would be discounted relative to those further away and that this discount would become more severe after a negative environmental event. However, the results in the exhibits indicated that, while both of these effects were observed in some cases, neither was universally true. There also appeared to be substantial differences in the patterns of the coefficients between the Mobil areas, the western Murphy areas, and the eastern Murphy areas.

Exhibit 3
Model 1 Results, Time Periods T4, T5 and T6

	Model 1, T4 1979–1983 Adj. *R*-squared = .749 495 Cases			Model 1, T5 1984–1988 Adj. *R*-squared = .748 762 Cases			Model 1, T6 1989–1991 Adj. *R*-squared = .776 742 Cases		
Area	***B***	**S.Err. *B***	***p*-level**	***B***	**S.Err. *B***	***p*-level**	***B***	**S.Err. *B***	***p*-level**
MB1	3485	2080	.094	1940	2002	.330	1001	2283	.661
MB2	1503	1644	.361	−1217	1725	.480	1243	2456	.612
MB3	2597	1756	.139	−3335	1930	.084	−6341	1811	.003
MB1W	4567	1579	.004	−3297	2217	.137	1637	2054	.425
MP2W	4546	1544	.003	5014	1777	.004	5661	2235	.011
C10	2289	1840	.214	3089	2113	.144	5725	2368	.015
MP3W	4870	1632	.003	777	1719	.650	4166	1994	.037
MP1E	−3572	1674	.033	−149	2803	.957	2356	3471	.497
MP2E	1972	1657	.234	1403	1863	.451	−726	2017	.718
MP3E	1222	2356	.604	4658	1633	.004	6421	1572	.0004

Source: Flower (1993)

The area closest to the Mobil refinery (MB1) was priced at a premium with respect to the more distant areas in all time subsets except T2 (82–83). The significant $6,092 premium for MB2 (the second Mobil area) relative to MB1 in the 1982–83 period suggested that the environmental events during that period had an effect. Before and after this brief interval, the area closest to the refinery was valued at a premium relative to the areas further away, indicating the impact dissipated shortly after the worst of the publicity.[13] None of the results from the other time periods indicated a significant proximity effect. The results supported the notion that the area close to the Mobil refinery was viewed as being prestigious and that the buffer zone was sufficient to minimize any negative impacts from the refinery. In terms of the Starrett model, it is likely that some "sorting" has occurred.

The two areas closest to the west side of the Murphy refinery (MP1W and MP2W) exhibited no significant differential in T1 (79–81), T2 (82–83) and T4 (79–83), but there was a very significant premium in excess of $5,000 for MP2W relative to both MP1W in T3 (84–85), T5 (84–88) and T6 (89–91). Recalling that the MP1W area was separated from the processing equipment by a negligible buffer zone, the result was consistent with the existence of a significantly negative net proximity effect. However, the net impact could also be influenced by the positive influence of the school in the more distant area. As with the Mobil area, the intangible influence of "sorting" may be a factor.

On the eastern side of the Murphy refinery, a significant net negative proximity effect was suggested by the relative values of MP1E and MP2E in the 1979–83 period, but the coefficients for both these areas were insignificant in the 1984–88 and 1989–91 periods. However, the coefficient for the MP3E area was a highly significantly positive value in each of the latter periods. This changing pattern could imply that a significant proximity effect present in the first period either diminished or shifted outward. However, the development of a prestigious, upscale subdivision after 1984 could have contributed to the relatively high value for the MP3E area in the latter periods. The unusual aspects of MP1E noted previously and the resulting very low number of transactions in the MP1E area during 1984–88 and 1989–91, could also have affected the empirical results.

Model 2

Model 1 was structured to allow for and detect different impacts related to the two refineries, while pooling all data in a given time period. It was believed to be the best possible specification for that purpose, but the use of dummy variables to capture proximity impacts only provides information regarding a shift in any price gradient that may exist. Model 2 was included in this study to search for a significant specification of the actual distance relationship. In order to detect how price changes with proximity distance, various specifications using the minimum distance from a particular refinery's processing area were used in hedonic regressions. To minimize a confluence of effects from the two refineries, the available data was divided into three segments, whereby each could be considered influenced primarily by only one of the refineries. The Mobil area was defined as all sites where the distance from R3 (eastern Mobil point indicated on Exhibit 1) was less than R4 (western Murphy point). The Murphy facility was defined similarly by reversing the inequality. Since the results of Model 1 suggested that the east and west proximity areas of the Murphy refinery were different, the Murphy data set was divided into east and west segments and regressed separately.

The distance used in the regressions of the Mobil data set was the minimum distance from any of the three reference points (R1, R2 and R3). For the west and east Murphy sectors, distance was calculated from reference points R4 and R5, respectively. Each of the three data sets (Mobil, Murphy west and Murphy east) was divided into the time segments corresponding to periods T4, T5 and T6 of Model 1 (1979–83, 1984–88, 1989–91). For each time subset, a series of regressions was estimated for each of four dependent variables (Price, log Price, Adjusted Price, and log Adjusted Price) against specifications that potentially could reflect the hypothesized relationship between the dependent variables and distance—that is, that price increases with distance, but the rate of increase diminishes with distance. The specifications of the distance variable that were tested included a cubic polynomial,[14] a quadratic polynomial, a linear equation, the natural log of distance, the inverse of distance, and the square root of distance.[15] All the noted specifications were used in regressions for three "Time" segments of the data sets established for the Mobil, western Murphy and eastern Murphy areas.

The results for each of the defined areas are examined in turn in the following paragraphs. Only the most significant of the specifications for the three area data sets are tabulated and graphed.

Mobil Area The results in Model 1 for time subsets T4 (79–83), T5 (84–88) and T6 (89–91) suggested that if there was any proximity effect at all for the Mobil area, prices declined with distance rather than increased as hypothesized. This result was

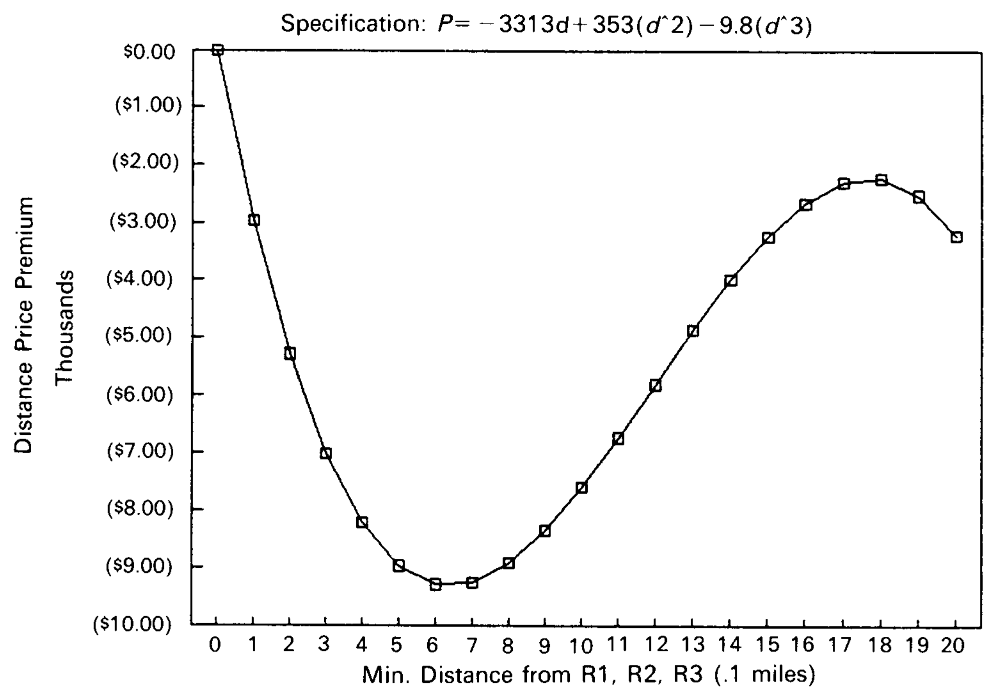
Exhibit 4
Model 2 Results, Mobil Refinery Area

Time Period	No. of cases	Coefficients (*p*-level)		
		D	D^2	D^3
1979–1983	166	−3313 (.018)	353 (.006)	−9.77 (.004)
1984–1988	268	−1321 (.400)	116 (.37)	−3.06 (.330)

Source: Flower (1993)

confirmed by the Model 2 regressions. The only distance specification that was significant (the null hypothesis significantly rejected) was the cubic polynomial and that was only significant for the period 1979–83. This result was recapped in Exhibit 4 for the regression on the nominal price-dependent variable (the results using the adjusted price variable were virtually the same). The nonsignificant result for the

Exhibit 5
Proximity Distance from Mobil, 1979–83



Source: Flower (1993)

1984–88 period was also tabulated for contrast. The negative signs of the linear and cubic terms indicated values decreased as distance increased, a result in conformance with the Model 1 result but opposite to the expected proximity effect.

The absence of any significantly negative proximity specification obviously suggests that any negative refinery impacts were either offset or diminished by other factors. This evidence supports the appraisers' views regarding the appeal of the area near the Mobil refinery. It is also consistent with Starrett's concept of "sorting" based on personal preferences. Another likely factor is the existence of the substantial buffer zone in front of the Mobil refinery described previously.

In accordance with Model 1 and contrary to the hypothesized effect, these estimated coefficients indicate prices are decreasing as distance increases. This fact is depicted graphically in Exhibit 5, which portrays the predicted impact on price of the estimated distance function. As noted by Rosen (1974), Freeman (1974) and others, the implicit price estimated with a hedonic regression cannot be generally interpreted as a demand function, and the graphs presented in this section are only intended to illustrate the general shape of the estimated function, not to define a price-to-distance demand function.

Western Murphy Sector The Model 2 regressions on the area west of Murphy also supported the Model 1 results. In the first time subset (1979–83), there was no significant distance specification, but in the second and third time periods, significant specifications indicating a proximity effect were estimated. For the 1984–88 period, there were a number of specifications with significance levels below 5%. The square root of distance, the natural log of distance, and the inverse of distance were all significant in regressions using all of the four dependent variables; a linear specification of distance was significant using the adjusted price and log of adjusted price as dependent variables. The specification with the highest R-squared value and best significance level was the regression of the natural log of the distance. Regressions using the adjusted price (ADJ$) and log of adjusted price (lnADJ$) as the dependent variable were both significant below the 3% level, with the lnADJ$ regression providing slightly better significance. Similar results were obtained using the nominal price as the dependent variable. The regressions on the 1989–91 subset also had significant distance specifications. Again, the specification with the lowest p-level was the regression of the natural log of distance. The results for both the 1984–88 and the 1989–91 periods are listed in Exhibit 6.

The sign and magnitude of the estimated coefficient were reasonable and consistent with the hypothesis that the more distant sites were valued higher than those in close proximity. In addition, recognizing that coefficients in the period before and during the environmental events (1979–83) were insignificant, the very significant coefficients in the second time period were consistent with the hypothesis that the environmental "events" impacted property values and caused an increase in the "distance" price gradient. The estimated specification using the natural log of distance supported the hypotheses that the relationship between proximity distance and property value was nonlinear in nature, and that it was significant across a limited range.

Using the specification with the natural log of adjusted price as the dependent variable, and evaluating the derivative of the estimated functions for the 1984–88 and 1989–91 periods at the mean values of *Adjusted Price* ($64,717; $67,472) and *Distance*

Exhibit 6
Model 2 Results, Western Murphy Sector

Dependent Variable	Est. *B* [ln (*d*)]	Std. Err. *B*	Adj. *R*-Sq	*p*-level
Total Area, 1984–1988 (139 Cases)				
Adjusted Price	3682	1621	.778	.025
ln (Adj. Price)	.0455	.0193	.790	.020
Total Area, 1989–1991 (141 Cases)				
Adjusted Price	5700	1857	.839	.003
ln (Adj. Price)	.0485	.0196	.863	.015
.5 Mile Subset, 1984–1991 (68 Cases)				
Adjusted Price	3040	1610	.744	.065
ln (Adj. Price)	.0512	.0278	.727	.070

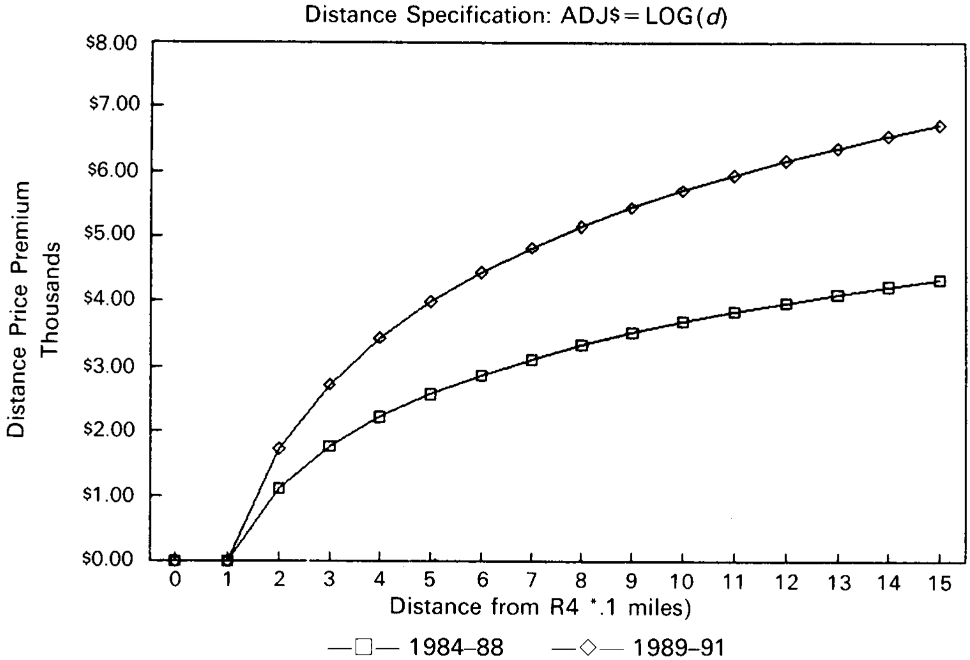
Source: Flower (1993)

(8.18; 7.75), the marginal price of *Distance* is calculated to be \$357 for the 1984–88 period, and \$379 for the 1989–91 period. Given the shape of the estimated specification, it is reasonable to expect a higher marginal price for sites in closer proximity, and less for those further distant.

It was noted above that the Model 1 results, while consistent with the premise that the refinery negatively impacted the properties in the closest area, could also be attributed to the presence of positive influences in the more distant areas. The significant Model 2 distance specifications for the west Murphy areas provided greater support to the view that at least a substantial part of the estimated differential was due to a negative influence on the properties closest to the refinery. The most tangible explanation for the existence of this significant impact, given that none was evident in the Mobil area, was the lack of an effective buffer zone on the western side of the refinery.

To investigate this important point further, a subset of the data including only properties with .5 miles of the western Murphy reference point (R4) was created. As noted above, there was very little separation between the processing equipment and nearby homes in this area. This data subset was used with a modified Model 2 specification to estimate a distance effect.[16] There were 100 cases in the total subset for all thirteen years, and of these, 68 were from the period 1984–91. Regressions were estimated using various distance specifications for the total subset, the 1979–83 period, and the 1984–91 period. Considering the longer time interval involved, the adjusted price was used as the dependent variable. The distance variables in the 1979–83 regressions were not significant at probability levels less than 18%. However, in the 1984–91 subset, several specifications were significant at the 6% level. The regression using the natural log of distance had the lowest probability levels. Again using the specification with the natural log of adjusted price as the dependent variable, and evaluating the derivative of the estimated function at the mean values of *Adjusted Price* (\$63,950) and *Distance* (3.32), the marginal price of *Distance* was calculated to be \$986 for the period. The substantially higher marginal price calculated with this

Exhibit 7
Western Murphy Sector, 1984–88, 1989–91



Source: Flower (1993)

model, as compared to those reported above, confirmed the previously stated expectation that the sites in closer proximity are impacted more than those further distant. It also supported the notion that at least a substantial percentage of the relative value difference estimated with Model 1 was attributable to the refinery, as opposed to positive factors in the more distant areas.

As with the Mobil results, an illustration of the estimated distance functions for the 1984–88 and 1989–91 subsets is depicted in Exhibit 7. The same caution regarding the interpretation of this graph applies.

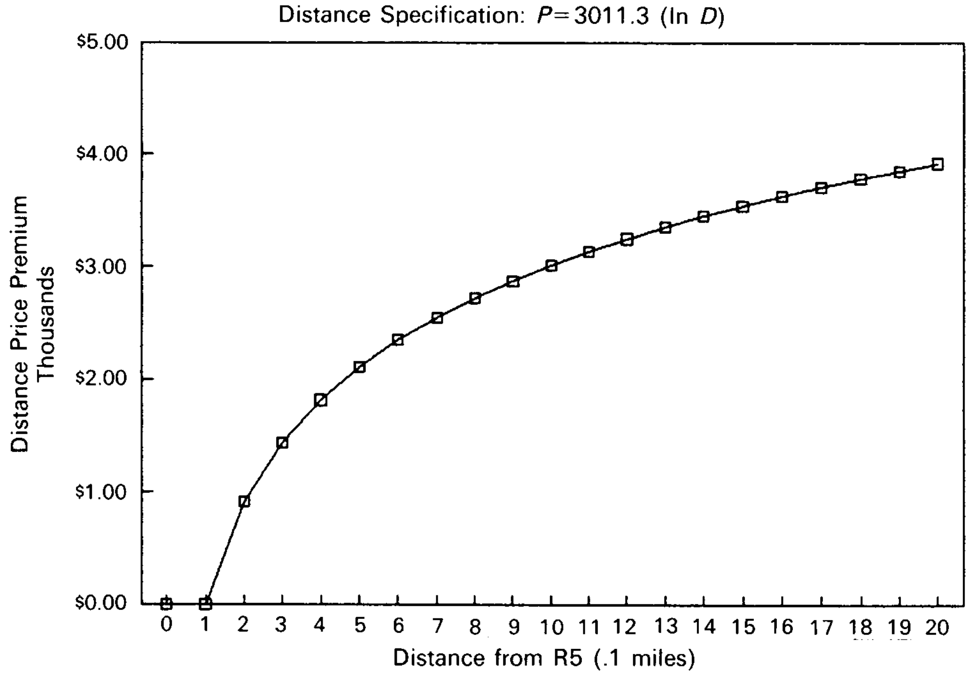
Eastern Murphy Sector The sites on the eastern side of the Murphy refinery were also divided into the three time subsets (79–83; 84–88; 89–91). The regressions of the first time subset had very significant results for the cubic polynomial, natural log of distance, and the inverse of distance. The probability level for the square root of distance was 11%. The results for all these specifications supported the hypothesis that value increased nonlinearly with distance from the refinery. The regression result using the natural log of distance, which had the best significance level for the 1979–83 period, is summarized in Exhibit 8. The shape of this estimated function is illustrated in Exhibit 9. The significant specifications in the first period bolstered the Model 1 result, which indicated a significant discount for the closest area relative to the second area. However, no significant results were detected in either of the latter two time

Exhibit 8
Model 2 Results, Eastern Murphy Sector

Dependent Variable	Est. *B* [ln (*d*)]	Std. Err. *B*	Adj. *R*-Sq.	*p*-level
Total Area, 1979–1983 (215 Cases)				
Adjusted Price	3011	1134	.710	.008
ln (Adj. Price)	.0518	.0186	.710	.006

Source: Flower and Ragas (1994)

Exhibit 9
Eastern Murphy Sector, 1979–83



Source: Flower and Ragas (1994)

periods using any of the above-mentioned Model 2 specifications. In this regard, the Model 2 results failed to confirm the outer movements of the proximity effect in the second and third time periods which were implied by the Model 1 results. The Model 2 results for periods two and three suggested that the proximity impact evident in the 1979–83 period diminished in the latter periods, but as noted in the discussion following Model 1, the small number of observations in the latter periods might have screened any significant impacts.

Conclusion

Perhaps the most interesting aspects of the empirical study described here are the contrasting impacts of the two refineries, and the associated evidence that locational preferences and the quality of the buffer zone have jointly influenced the capitalization of the negative refinery factors in this relatively small and isolated community. While the possible influence of tangible factors omitted from the models is recognized, there is reason to believe that "sorting" has diminished the degree of capitalization in the Mobil areas. In most of the time subsets considered, a negative proximity effect is not evident in the areas around the Mobil refinery. The single exception is the temporary relative premium for the more distant area (MB2) over the closest area (MB1) noted for the 1982–83 period. This lone example of a significant negative impact from the Mobil refinery was detected during the time of the adverse publicity regarding both possible health risks and the tank fire at that refinery. The fact that no such effect was detected in later periods could indicate that the impact was the result of temporary concern caused by the fire. It may also be attributed to a combination of diminished publicity, the lack of objectionable sensory reminders, and the market's short memory. The temporary nature of the impact conforms with the previous studies of Kinnard and others, who found that some events have a temporary impact on values.

In contrast, a significant negative impact is evident near the west side of the Murphy refinery for the periods after the environmental event (1984–88 and 1989–91). This enduring impact suggests a permanent change in perceptions. The difference in the buffer zones separating the two refineries from the residential areas is visually obvious, and it is likely that this distinction contributes to the disparity in the detected capitalization. In the area west of the Murphy refineries, residents and potential buyers are sensorially reminded of the refineries' shortcomings more frequently. The study also notes expert opinions that intangible factors such as the "prestige" of certain neighborhoods, plus the existence of positive attributes not incorporated in the models, tend to minimize the detected capitalization in the Mobil areas, while accentuating the degree of capitalization detected in the Murphy areas.

While there may be other factors contributing to the lack of a Mobil impact, the advantage of a larger buffer zone seems clear. The Bleich, Findlay and Phillips (1991) article regarding a well-designed landfill establishes the benefits of such zones in conjunction with solid waste landfills, and Colwell (1990) indicates that the screening provided by trees may be responsible for diminishing the impact of transmission lines. The same logic appears to apply for refineries.

This implied policy favoring buffer zones has apparently been embraced in at least one instance by Exxon. As noted, it has an ongoing, voluntary, acquisition program of all available properties within approximately one half mile of its large refinery in Baton Rouge, Louisiana. Undoubtedly, the distance that constitutes an "adequate" buffer zone is dependent on the characteristic of a specific plant, and various other factors. The previously cited literature on landfills indicates the advantages of space and screening by natural features such as hills or trees. With regard to a refinery, this study suggests that other important factors are the existence and width of bordering streets, the type of construction fronting the refineries, the configuration of the residential streets, the orientation of the housing on the streets, and the attitudes of the neighboring residents. Further research is needed to establish the optimum buffer criteria for refineries and similar types of facilities, but such information would be useful to both industry and public planners.

Notes

[1]Class action suit by Kevova, West Virginia against Ashland Oil: "Jobs vs. Clean Air: Suit Against Refinery Divides Quiet Town Into Bitter Battlefield," *Wall Street Journal*, September 9, 1990, A1.

[2]Complaint campaign by Fairlea Subdivision, Port Arthur, Texas prompted Fina, Inc. to purchase properties: "How A Neighborhood Talked Fina Refinery Into Buying It Out," *Wall Street Journal*, December 10, 1991, A1.

[3]Between September 1989 and September 1992, Exxon Corp. has purchased 271 properties within one half mile of its fence line. This information was obtained from the records of the Baton Rouge Clerk of Court.

[4]See Congressional Subcommittee, July 1890.

[5]Hedonic theory is based on the hypothesis that goods are valued for their utility-bearing attributes. Given a class of differentiated but closely related products (such as houses), the hedonic technique uses a regression of the prices of a set of the differentiated products on the associated significant attributes that characterize those products. The coefficients estimated for the various attributes are interpreted as the equilibrium implicit prices of those characteristics.

[6]See Flower (1993) for a detailed discussion of this study and a comprehensive listing of the empirical results.

[7]The use of hedonic techniques to construct an index of real estate prices has been discussed by Griliches (1971), Palmquist (1984), Case and Shiller (1987), and others. Three basic methods have been employed: (1) a hedonic regression using the pooled sample of transactions with time dummy variables (see Palmquist for a more detailed explanation of the procedure); (2) a series of two-year regressions, with the results combined to construct the index; and (3) hedonic regressions using repeat-sale properties only (Case and Shiller propose a three-stage procedure to estimate a "Weighted Repeat Sales" index). Unfortunately, the repeat-sale method required a very large database with an appropriate number of resales—a database that could not be accumulated from a census of sales in the study area. Both other methods were tried, but only the first method produced a reasonable index (the lack of success with the second method can be attributed to the relatively small number of transactions in some of the years). As noted by Griliches and Palmquist, the method used has limitations, and as such, the models in this paper were regressed using both nominal and "adjusted" prices as the dependent variable. The study results were robust for both.

[8]I would like to acknowledge and thank Mrs. Janice Kannair and Mr. Charles Ruffino for their assistance. Both are long-time residents of the parish and are recognized as experts in the St. Bernard residential real estate markets.

[9]This area is the original Chalmette, with which many St. Bernard residents have traditional family bonds. The neighborhood remains a safe place to live where residents enjoy a high degree of familiarity and interaction.

[10]Given the structure of Model 1, the environmental proximity effect is indicated by a significant difference in the coefficient of two adjacent areas, and such a relative comparison can be made using the transformation estimate, as well as the linear and semi-log specifications. A comparison of regression results using the transformation, a linear specification, and a semi-log specification indicated the results pertaining to the environmental variable are robust for all of these specifications.

[11]The "p-level" shown with the regression results indicates the probability that the "true" value of the coefficient is actually zero; it can be interpreted as the significance level at which the null hypothesis that $b=0$ can be rejected.

[12]In general, the explanatory power of the models used in this study was very good, with adjusted R-squared values that ranged from .68 to .84, and were usually well above the .70 level. The correlation matrix for the various models was examined for problems related to multicollinearity. The matrixes indicated very low correlation between any of the housing characteristic and the time variables (.18 or less), and acceptable levels of correlation between the housing variables themselves (the highest were bedrooms (.47) and baths (.51) with respect to living area; all other correlations were below .35). The coefficients for the variables all had reasonable signs and magnitudes.

[13]As noted previously, such temporary impacts from environmental externalities are reported by Kinnard (1991). A diminishing effect from power lines was also noted by Colwell (1990).

[14]Although not generally used in the literature, the cubic polynomial was included since it could capture a "stepped" or "plateau" effect, should one exist. It also could describe the hypothesized price-distance relationship—price increases at a diminishing rate as distance increases.

[15]Regressions considered other specifications compatible with the hypothesized price-distance relationship described above, such as various root functions of distance. In general, the regressions with these specifications had lower R-squared values and less significant coefficients for the distance variable than the reported specifications.

[16]The number of explanatory variables was reduced as compared to the other Model 2 specifications. This change was made because of the lower significance level of some of the explanatory variables in this smaller data set.

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