The Effect of Underground Storage Tanks on Residential Property Values in Cuyahoga County, Ohio

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Abstract. **This study considers the effect of underground storage tanks on residential sales price. These effects are tested with a hedonic pricing model for all 1992 residential sales in Cuyahoga County, Ohio. Three types of tanks were tested: non-leaking tanks registered with the State of Ohio, leaking tanks that are currently not registered, and registered leakers. Results show that close proximity (same block or within 300 feet) to registered, non-leaking tanks and to unregistered leakers did not significantly affect sales price. However, proximity to a leaking, registered tank demonstrated a reduction in price of over 17%.**

Introduction

This research investigates the relationship between both leaking and non-leaking underground storage tanks on residential sales values. We focus on one urban county and use registered tanks and known leaking tanks during the 1988–1993 period. The data source for the tank information is the State of Ohio's Bureau of Underground Storage Tank Regulations (BUSTR). We study 16,990 residential sales in Cuyahoga County, Ohio during 1992. A total of 83 residential sales were close enough to underground storage tanks to be featured in our analysis.

The rest of the paper provides a literature review, a discussion of the model and data sets used, and a map of most tank sites. We provide a hedonic model of residential sales, which includes three types of underground tanks. Where residential sales are close to tank sites, we find the expected negative effect on nearby residential sales among tanks that have *both* the nuisance effect of an ongoing business and a reported leak. Close proximity to either an unregistered leaking tank site or to a site with registered tanks that had not leaked had a small negative sign, not significantly different from 0. We believe our research is the first to address the relationship of UST (underground storage tanks) to residential property values.

Literature Review

There is a well-documented relationship between the nuisance and hazard effect of the by-products of economic development and their negative effect on surrounding

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residential property. Studies have been conducted on Superfund toxic waste sites by Kohlhase (1991); on landfills by Thayer, Albers and Rahmatian (1992), Reichert, Small and Mohanty (1992), Nelson, Genereux and Genereux (1992), and Smolen, Moore and Conway (1992); existing hazardous waste sites by Michaels and Smith (1990), Kiel (1994), and Thayer, Albers and Rahmatian (1992); and proposed radioactive waste sites by Michaels and Smith (1990). Other studies on related negative externalities have been performed on high voltage and transmission power lines by Delaney and Timmons (1992), Colwell and Foley (1979), and Colwell (1990). Additional research on the relationship between groundwater contamination and residential values has been performed by Page and Rabinowitz (1993). We are not aware of any studies on underground storage tanks and their relationship to residential property values.

Results from available studies generally support the notion that there is a negative relationship between proximity to these sites and residential sales values. This relationship becomes less apparent with increasing distance from the site, tapering off to no effect at some distance, depending on how large the site is. The nature of the toxicity can also affect the reduction in values. Thayer et al. (1992) found a larger negative effect for hazardous waste than for nonhazardous materials.

The mechanisms by which apparent negative effects of proximity to proposed hazardous land uses are capitalized into lower housing values include the markets' assimilation of publicly available information, especially the announced plans of government agencies (Kiel, 1994; Kohlhase, 1991; Smolen et al., 1992). Homeowners may also perceive separate diminution of value attributable to a nuisance associated with close proximity to a site, as well as more general negative effects related to potential health hazards as per Reichert et al. (1992). Proximity to visually obvious hazardous sites may also deter potential buyers from making offers on homes, thus affecting sales price by reducing demand.

Measurement of the proximity to environmentally objectionable land uses was typically measured from only one site, or the nearest site. Most of the studies have employed a concentric ring approach, with distance typically measured in quarter-mile increments from the subject site. Colwell (1990) and Colwell and Foley (1979) used a nonlinear decay function for distance from pre-identified power lines and time after sale.

Nearly all the studies cites have focused on a very small number of large, contaminated sites. We have a highly dispersed set of sites over 2,500 tank locations, with differing levels of actual or potential land-based toxic releases. All our sites were active or had leaks during the 1988–1993 period. We use the conventional definition of a tank leak, which excludes surface spills and includes leaks from below the plumbing union where the dispensing unit meets the underground storage tank. We measure relatively small distances, e.g., within several hundred feet.

The Model

We employ a multiple regression model where the unit of observation is individual parcels. The hedonic platform features residential sales as the dependent variable to be explained. Proximity to a registered or leaking tank site is included as one of several independent variables, the others being property characteristics, location and season of sale. This approach is similar to that employed in other studies concerned with the effect of proximity to environmentally objectionable sites to property value (Colwell, 1990;

Kohlhase, 1991; Nelson et al., 1992; Reichert et al., 1992; Smolen et al., 1992; Thayer et al., 1992).

Our hedonic model is based upon an hypothesized relationship between residential sales price and a set of explanatory variables. As suggested by Rosen (1974), there are theoretical grounds to believe that relationships between these variables may be nonlinear. To determine the appropriate functional form of the model, the general form employed is:

$$Y^{\lambda 1} = \beta_1 + \beta_2 X_2^{\lambda 2} + \ldots + \beta_N X_N^{\lambda N} + \varepsilon \,, \quad (1)$$

where the parameters λ are estimated from the data using the power transformation introduced by Box and Cox (1964), and elaborated upon by Spitzer (1982).

For this research, separate λs were estimated for four key continuous variables: sales price, building square footage, age, and lot frontage. Therefore, the following model was employed:

$$PRICE^{\lambda 1} = \beta_1 + \beta_2 BLDSQFT^{\lambda 2} + \beta_3 AGE^{\lambda 3} + \beta_4 LEGFRONT^{\lambda 4} + \beta_5 UNIT + \beta_6 ZIP + \beta_7 SEASON + \beta_8 TANK + \varepsilon \,, \quad (2)$$

where the notation is:

PRICE = sales price of the residential unit;
BLDSQFT = interior building square footage;
AGE = age of the house;
LEGFRONT = legal front footage of the lot;
UNIT = a vector of other housing unit characteristics, including bedrooms, rooms, condition, bathrooms, fireplaces, garages, double (duplex unit) and style; and lot depth;
ZIP = a dummy variable for zip code is used as a proxy for a vector of census tract and municipal characteristics, including distance to CBD, housing vacancy, income, race, and crime rates;
SEASON = Proxies for the spring, summer, fall, and winter sales seasons;
TANK = a dummy variable if there are known leaking, non-leaking registered underground tank(s), or leaking and registered tanks present very near the property (e.g., same block or within 300 feet).[1]

Because of the difficulty in interpreting the β-coefficients from a model that has undergone a Box–Cox transformation, a linear version of (2) is also presented to provide useful information on the effect of key variables on sale price.

Data Sets

This research utilizes several data sets, which are merged to produce a combined database. These include property tax records, real estate sales, the TIGER/Line address files, and information on underground storage tanks.

The main data set is the Cuyahoga County Auditor tapes, which contain property characteristics and land use, property tax billing data such as market value, and deed and mortgage records for the approximately 650,000 parcels in the county. The computerized data provide property characteristics for the hedonic platform. This database is keyed on a unique permanent parcel number (PPN). It can readily be merged with the Amerestate files, which contain real estate sales and mortgage financing data, some property characteristics, and PPN.

The TIGER/Line files are used for computer mapping with a GIS software package. In the process of address matching, TIGER provides latitude and longitude coordinates for all sites successfully plotted. We use these maps to determine trends and patterns in tank locations.[2]

Our main environmental data set contains information about the presence of underground storage tanks located in Cuyahoga County. Records date back to 1988. The State of Ohio Bureau of Underground Storage Tank Regulations (BUSTR) requires registration of all underground tanks currently in use that contain hazardous substances as defined in CERCLA section 101(14). This generally includes all petroleum products. Farm tanks, septic tanks, water tanks, small tanks (under 110 gallons), and tanks storing heating oil for personal use are excluded from regulation. The data set includes tank address and selected attributes such as number, type, content, and age of tanks on each site. The computer-readable component of the leaking tanks data is much less complete, and only includes year of release and a partial address. The data used in this research covers Cuyahoga County, and is derived from information provided by BUSTR. The data set contains 1,678 registered sites and reports of 1,362 leaking underground storage tank sites, as of mid-1993. Interestingly enough, only about 39% of the leaking tanks are on the current registered list, implying that some tank leaks were a "surprise," and that others that leaked had the tanks on site removed, and were deleted from the current registry list. To the best of our knowledge, this tank data set has not yet been used in research.

A study by Bowen, Salling, Haynes, and Cyran (1995) developed a hierarchy of measuring toxicity for various types of noxious environmental releases, based in part on an ACGIH technical document (1991). According to this approach, leaking storage tanks could be classified as a land-based release, and are expected to have a small, localized effect. We interpret this local area to be within visual sight distance or a city block (about 300 feet). We therefore expect relatively small effects from the leaking tanks on surrounding residential property because it is a land-based toxic release, and expect that the effect would be limited to the immediate vicinity, unless there is groundwater contamination. This notion is supported by Patchin (1994) who asserts that the market value stigma associated with environmentally suspect sites should be less severe if there is contained soil, as opposed to off-site groundwater contamination. Information about the extent of the leaks may vary also substantially. These data, however, are not currently available. We also expect that there is a nuisance factor of an ongoing business (e.g., gas station), the negative effect of which should be capitalized into residential sales price.

Exhibit 1 shows selected descriptive statistics and variable names for the housing variables and tank variables used in our model. Because housing hedonics are not the focus of the paper, we cover only the tank variables in detail here. The mean residential sale in 1992 sat on a lot with 59 feet of frontage and an average depth of 164 feet. The units sold were a mean age of fifty-one years, averaged 1,608 square feet, with 3.3 bedrooms, 1.3 baths, and space for 1.6 cars in the garage. Average sales price was $86,500.

Exhibit 1
Descriptive Statistics on Housing and Tanks Variables Used in the Model

Variables	Mean	Std Dev.	Details on Measurement
Housing Variables			Number of observations=16,990
LEGFRONT	58.49	34.70	Legal lot frontage, in feet
AVEDEPTH	163.87	116.38	Average lot depth, in feet
BLDSQFT	1607.58	655.95	Building square footage
ROOMS	6.81	2.00	Number of rooms in 1992
BEDROOMS	3.26	0.92	Number of bedrooms, 1992
AGE92	50.91	24.15	Age of building in 1992
BATHS	1.34	0.57	Rooms that are bathrooms
FIREPLACE	0.37	0.55	Number of fireplaces, 1992
QUALITY	3.29	0.57	Quality index on 1–5 scale
GARAGE	1.62	0.97	Garage capacity (spaces), 1992
PRICE	86535.00	64481.00	Sales price in 1992
DOUBLE	—	—	Dummy variable for duplex (12%)
ZIP	—	—	Dummy variable for 50 zip codes
STYLE	—	—	Dummy variable for 5 housing styles
SEASON	—	—	Dummy for 1 of 4 sales seasons
Tank Variables			
CLOSLUST	554*	—	Dummy variable for proximity to leaking, unregistered tank
CLOSTANK	883*	—	Dummy variable for proximity to registered UST, not leaking
CLOSRGLK	446*	—	Dummy variable for proximity to leaking and registered tank

*The number of tank sites used in the statistical analysis for potential matching with residential sales. Of these, only 83 actually were proximate to a residential sale in 1992.

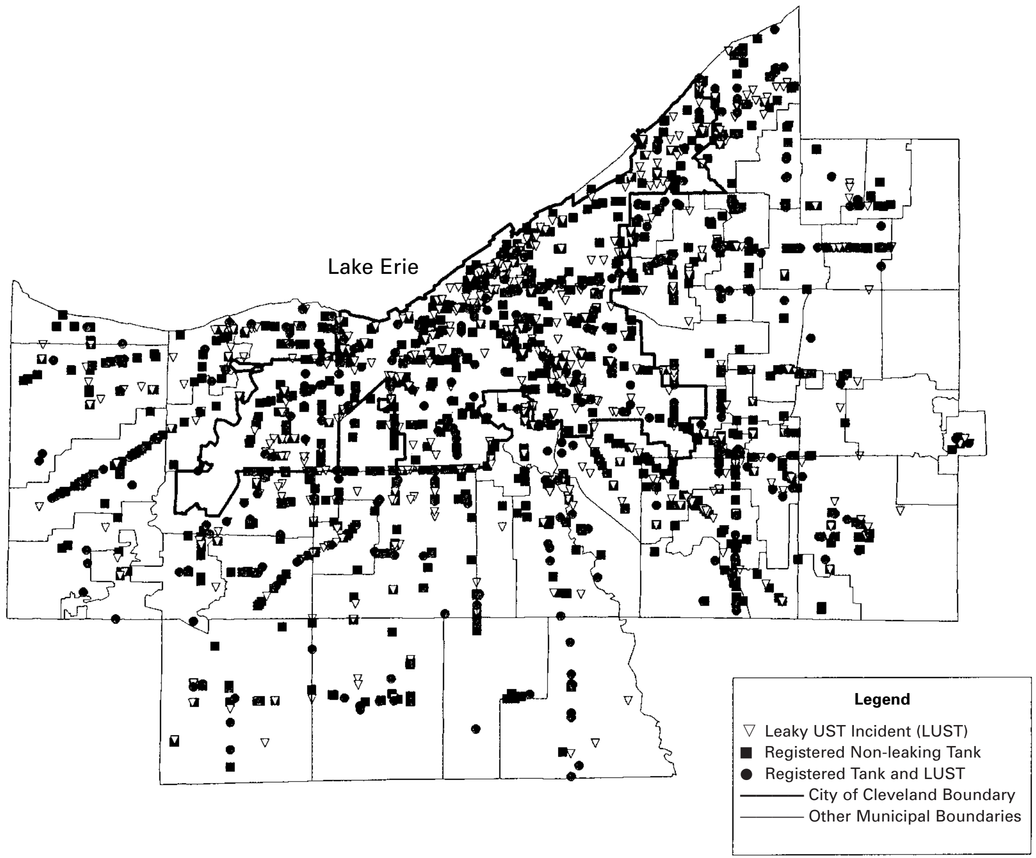
Source: Authors

Placing Underground Storage Tanks Sites in Real Space

We had substantial success in applying geocode addresses and PPNs to tank sites and residential sales. Out of a total of 2,513 tank sites, 835 were leaking unregistered tank sites (75% geocoded, 66% with PPNs), 1,151 were registered non-leaking tanks (82% geocoded, 77% with PPNs), and 527 were registered leaking tanks (90% geocoded, 85% with PPNs). We also report on over 16,900 residential sales from 1992 (89% geocoded, 100% with PPNs).[3]

In the hedonic model including tank data, we use a near-perfect match on PPNs as a measure of proximity for three categories of tank: *CLOSLUST* (close to a known leaking but currently unregistered tank), *CLOSTANK* (close to a registered, non-leaking tank site) and *CLOSRGLK* (close to a registered tank site leak incident). This PPN matching technique is believed to capture over half of the sales located near tanks, and gives a measure of proximity between tanks and residential sales that is accurate within an average of five parcels, on either side.[4] We interpret this level of proximity to reflect residential sales "on the same block" as a tank. Further examination of property tax

Exhibit 2
Registered Underground Storage Tanks and LUST Incidents in Cuyahoga County, Ohio



Source: Ohio BUSTR; 1990 TIGER/Line Census Files maps verified that all sales were, in fact, on the same block or within 300 feet of the tank site. We also conducted field inspections on a sample of approximately twenty-five sales proximate to leaking tanks to rule out incompatible land uses (e.g., school athletic fields) and verify that the properties were still in residential use.[5]

Because our loss of information for tank data using PPNs was relatively low, we have a moderate level of confidence in our ability to generalize from our tank sample to the population. However, unregistered leaking tanks was the weakest group, and most likely to have incomplete addresses. Over 500 hours of work went into compiling acceptable PPN and geocoded address data.

Exhibit 2 is a map of the three types of tanks and residential sales. Squares denote registered tank sites that have not leaked during the 1998–93 period (*TANK*), circles represent registered tank sites that have leaked (*RGLK*), and triangles show surprise leaks that were not registered prior to the event, and/or those whose registry status was deleted after the leak event had run its course (*LUST*).

One evident pattern is that most tank site locations (i.e., gas stations) occur along main arterial streets. For example, it appears that non-registered leakers may be more likely found in clusters and in outlying areas, rather than along the main thoroughfares.

Statistical Results

Prior to performing regression runs, we generated univariate plots, and deleted outliers for the housing-related variables, where appropriate.[6] We also ran a correlation matrix, and did scatterplots of each variable against its own residuals and against the model residuals as a visual test for heteroscedasticity.[7]

The results of the Box–Cox hedonic model with housing characteristics, and zip codes, seasonal, and tank dummy variables, are presented in Exhibit 3. The model had an adjusted R^2 of .78, and an F-statistic of 862, which is statistically significant at α=.0001. Consistent with the very large data set, the model had 16,875 degrees of freedom. The linear model was nearly as robust, with an adjusted R^2 of .77 and an F-statistic of 791 (see Exhibit 4). Other nonlinear models were also run, but their performance was not as high as the Box–Cox or linear specifications. In general, unless otherwise noted, the statistical significance of variables in this study are cited from Exhibit 3, and the economic interpretations are derived from the linear βs from Exhibit 4.

Housing Variables: Results

The following housing-related variables were statistically significant at α=.01 or better: lot frontage, lot depth,[8] building square footage, rooms, age, baths, fireplaces, a quality index, forced air heat, garage, and a dummy variable for duplex unit. All variables except number of rooms and frontage had the expected signs. We interpret the negative sign on the rooms variable to reflect the functional obsolescence of older homes with many smaller rooms close to the city center. The seasonal dummies all had the expected negative sign, and winter and spring had a statistically significant price reduction compared with the reference category of the summer sales season.

Additionally, thirty-five out of the fifty zip code dummy variables were also significant at α=.05 or better. Because zips are control variables for location and not generally interesting to readers outside Cleveland, we include them in the Appendix exhibit. These

Exhibit 3
Results of the Hedonic Model Including Tank Variables, Box–Cox Specification

Variable	Parameter Estimate	Std Error	*T*-Stat.
Intercept	2542.93	64.81	39.23***
LEGFRONT	−1110.29	42.68	−26.01***
AVEDEPTH	00.006	0.007	0.40
BLDSQFT	00.00009	0.000002	44.10***
ROOMS	−2.71	0.80	−3.37***
BEDROOMS	−0.98	1.29	−0.76
AGE92	−1385.64	48.66	−28.48***
BATHS	26.53	1.97	13.44***
FIREPLACE	19.43	1.57	12.36***
QUALITY	60.93	1.94	31.47***
HEAT	−11.01	2.48	−4.46***
GARAGE	7.48	0.76	9.85***
DOUBLE	−75.47	3.19	−23.68***
STYLE1	3.27	6.88	−0.64
STYLE2	13.13	6.83	−1.92**
STYLE3	−0.29	6.87	−0.42
STYLE4	−5.67	7.18	−0.79
CLOSLUST	−16.40	17.56	−0.93
CLOSTANK	−4.87	13.83	−0.35
CLOSRGLK	−46.15	21.14	−2.18**
SPRING	−4.07	1.86	−2.19**
FALL	−2.48	1.86	−1.33
WINTER	−13.54	2.04	−6.64***

Adj. R^2=.78
F-Stat.=862.46***
Deg. Freedom=16,875

*significant at α=.1; **significant at α=.05; ***significant at α=.01
λ Values: *PRICE* 0.550; *LEGFRONT* −0.098; *BLDSQFT* 1.805; *AGE* 0.033

Source: Authors

results support the notion that certain zip codes (most likely those with homogeneous housing markets), acting as a proxy for location, school district and other services, are significantly related to sales price.

Results of Tank Variables

With respect to our tank dummy variables, we found eighty-three tanks located on the same block or within 300 feet as a residential sale in 1992.[9] These sales were scattered throughout the county. Because we considered the year of leak, we are certain that the sale (in 1992) occurred concurrent to or after a reported leak (1988–92, midyear).

A total of forty-two sales were close to registered non-leaking tanks, twenty-four were close to leaking unregistered tank sites, and seventeen sales were proximate to leaking tanks currently registered.[10] Through comparing owner names and visual site inspections, we also deleted several cases where there was an obvious change in land use

Exhibit 4
Results of the Hedonic Model Including Tank Variables, Linear Specification

Variable	Parameter Estimate	Std Error	*T*-Stat.
Intercept	−26376.00	4089.76	−6.45***
LEGFRONT	174.50	9.19	18.99***
AVEDEPTH	13.30	2.45	5.42***
BLDSQFT	46.41	0.76	60.92***
ROOMS	−2868.19	287.04	−9.99***
BEDROOMS	−3342.98	448.85	−7.45***
AGE92	−420.18	17.63	−22.83***
BATHS	14632.00	679.36	21.54***
FIREPLACE	5194.78	546.37	9.51***
QUALITY	19628.00	675.27	29.07***
HEAT	−3316.87	853.78	−3.89***
GARAGE	1509.80	262.99	5.74***
DOUBLE	−34485.00	1095.98	−31.47***
STYLE1	−2952.62	2382.00	−1.24
STYLE2	−64.89	2368.14	−0.03
STYLE3	−1056.35	2383.91	−0.44
STYLE4	−14479.00	2485.03	−5.83***
CLOSLUST	−1779.68	6335.29	−0.28
CLOSTANK	−3018.68	4909.64	−0.61
CLOSRGLK	−15152.00	7766.38	−1.95**
SPRING	−1522.56	643.23	−2.37**
FALL	−864.21	645.12	−1.34
WINTER	−4500.40	705.97	−6.38***

Adj. R^2=.77
F-Stat.=791.05***
Deg. Freedom=16,869

*significant at α=.1; **significant at α=.05; ***significant at α=.01

Source: Authors

for the residential sale (e.g., property bought by a fast food chain, supermarket, city, or church for purposes other than residential use).

The sign for proximity to a registered tank site, *CLOSTANK*, was negative, but was not significantly different from zero. These are generally tanks in active use. Therefore, the nuisance value of the activity associated with tanks, in and of itself, does not appear to be important, holding other variables in the model constant (especially age of unit, quality, double), which could be associated with residences built on or near main thoroughfares.

The variable *CLOSLUST* (known leaking tank, not currently registered) had a negative sign, and was not significantly different from zero. This category most often included commercial and industrial sites, some presumably inactive, as well as former gas stations and automotive uses. It also contained a lower than expected proportion of government and non-profit uses.

The third category of tank, *CLOSRGLK*, is for tank sites that have had known leaking tanks *and* are registered with the state BUSTR. This list includes many ongoing gas stations, industrial and commercial properties, car dealerships, and truck transport operations. We also have the best address matches for this group. The results show that for this variable, which combines the potential negative effects of both proximity to hazardous material and nuisance disutility, there is a negative sign which is statistically significant (in both the Box–Cox and linear models) at α=.05. The linear nature of the hedonic model allows the following interpretation of this variable: a residential sale located "on the same block or within 300 feet" of a registered tank site that is known to have leaked, could expect to sell for \$15,152 less, holding all else constant.[11] This price reduction, or negative proximity influence, represents 17% of the average 1992 residential sales price.

Conclusions and Policy Implications

This research has examined the relationship between three categories of underground storage tanks and their relationship to residential sales prices. Our hedonic model results provide evidence of a significant negative proximity influence on price when a residential sale is close to a registered tank site known to have leaked. In our sample, over three quarters of these leaking tanks involved soil contamination above mandated action limits and/or groundwater contamination. For non-leaking tanks and for leaking tanks no longer registered with the state, the impact of close proximity on sales price was not significantly different from zero.

However, our results do not include some known sites (i.e., those with poor-quality addresses), and also ignores a potentially important fourth group of tanks: those historical tanks from prior land uses that have not yet leaked but are present, undetected and therefore unregistered, in the county.

The number of sales proximate to tanks (eighty-three) is smaller than expected. While this may be partly due to our technique of finding tanks, it may also be attributable to a lower level of market activity for tainted property. This issue deserves more research.

While this research did not specifically control for proximity to commercial zoning or other nearby activity that does not have tank registry status, our analysis shows that proximity to a registered tank site (almost certainly a commercial use) does not in itself have a negative impact on sales price.

Further analysis should seek to improve upon the simple dummy variable for close proximity to a tank, (e.g., next-door property) and include more detail about the extent and type of leak, as well as date of leak relative to sales date.

The measure of proximity for tanks using match on permanent parcel numbers could be improved upon by utilizing a closer measure of proximity, or by employing geocoded latitude and longitude variables generated by an improved version of the TIGER/Line files. Tanks could also be examined to see if they affect nonresidential sale and financing activity of commercial and industrial properties. Another approach could be to identify serious leak events, then search closely proximate areas for residential sales activity. Finally, other sale years (1991, 1990, etc.) could be considered.

Another challenge is overcoming the lack of theory regarding the mechanisms by which information on toxicity and mode of release is converted into market outcomes. Sellers, for example, should have a better knowledge of leak events than buyers. This may manifest itself in a lower original listing price. If buyers are aware of the leaking tank, the property may spend a longer time on the market before it is sold. Also, notification of the presence of nearby underground storage tank leaks is required to be reported to BUSTR, but it does not in turn publicize the results. Also, the state did not require realtors/sellers to notify potential buyers of leaks in the vicinity until 1993, and then only for residential properties with on-site tanks.

The topic of underground storage tanks is an emerging field and represents many interesting and important research opportunities. One useful application could be for property appraisers to employ this information to determine the negative proximity influence of contaminated property on nearby residential and commercial sales prices.

Appendix

Exhibit 4A
Results of Zip Code Dummy Variables from Hedonic Model, Linear Specification

Variable	Parameter Estimate	Std Error	*T*-Stat.
B44022	80904.00	3316.43	24.40***
B44040	189888.00	11380.22	16.69***
B44070	6151.53	2486.28	2.47*
B44102	−18397.00	2383.46	−7.72***
B44103	−27652.00	3202.47	−8.63***
B44104	−29573.00	3313.79	−8.92***
B44105	−19691.00	2373.31	−8.30***
B44106	−11516.00	3205.86	−3.59***
B44107	16795.00	2305.05	7.28***
B44108	−32713.00	2931.59	−11.16***
B44109	−6051.19	2317.66	−2.61***
B44110	−16395.00	2690.73	−6.09***
B44111	−1627.83	2225.63	−0.73
B44112	−32343.00	2741.56	−11.78***
B44113	−1595.35	3397.12	−0.47
B44114	10049.00	10029.42	1.00
B44115	−81274.00	18068.79	−4.50***
B44116	33433.00	2657.12	12.58***
B44117	−4274.56	3239.02	−1.32
B44118	−14796.00	2273.52	−6.51***
B44119	−5284.03	2906.05	−1.82*
B44120	−12231.00	2476.77	−4.94***
B44121	−7082.36	2271.97	−3.12***
B44122	15399.00	2457.67	6.27***
B44123	−1603.51	2739.46	−0.59
B44124	23384.00	2298.66	10.17***
B44125	−1220.82	2408.23	−0.51
B44126	19568.00	2579.77	7.59***
B44127	−16003.00	3422.55	−4.68***
B44128	−19527.00	2717.12	−7.19***
B44129	14748.00	2493.56	5.91***
B44130	8425.16	2324.59	3.63***
B44131	2637.92	2800.89	0.94
B44132	−4057.60	2851.13	−1.43
B44133	−487.89	2856.56	−0.17

Exhibit 4A (continued)

Variable	Parameter Estimate	Std Error	*T*-Stat.
B44134	13542.00	2271.85	5.96***
B44135	−7365.32	2309.99	−3.19***
B44136	−13155.00	2329.69	−5.65***
B44137	−2974.96	2419.27	−1.23
B44138	1429.55	3182.14	0.45
B44139	11399.00	2664.13	4.28***
B44140	20455.00	2507.44	8.16***
B44141	5111.53	3185.12	1.61
B44142	10006.00	2753.05	3.63***
B44143	1164.50	2820.95	0.41
B44144	7439.08	2606.74	2.85***
B44145	8049.23	2576.24	3.12***
B44146	−6066.83	2603.55	−2.33**
B44147	8238.60	3602.04	2.29**

*significant at α=.1; **significant at α=.05; significant at α=.01

Source: Authors

Notes

[1]Theoretically, for reasons noted by Colwell (1990), nonlinearities in a proximity variable may be expected when the measurements reflect effects involving distance decay over time or space. Moreover, the nonlinear proximity variable specification used by Colwell is sensible given his research design. In this case, however, the nonlinear specifications are justifiable only for certain housing attribute variables. Our measurement of proximity is fundamentally different than Colwell's.

Colwell's research design pre-selects study areas in which he assumes the potential impacts are likely to occur, based upon proximity to power lines. The potential impacts are then operationalized as functions of distance from each parcel to the nearest point on the line, ignoring other points. This is a point-to-line analysis and the design is subject, in theory, to the criticism that the parameter estimates are biased with respect to the population, because of the non-randomness of the study areas.

In contrast, our research design starts out with an entire county and operationalizes the potential impacts as functions of distances between pairs of points within the county. However, rather than basing our analysis upon measurements between all possible combinations of points within the study region, we employed a dummy variable for proximity to tanks, based upon a perceived behavioral "zone of influence" (a city block, or within visual sight distance of about 300′) for a multitude of (about 2,500) scattered site "hot spots". This approach is, in theory, subject to the criticism that the distance measurements fail to capture the nonlinearities associated with distance decay.

To examine whether this theoretical criticism pertains to our study, we correlated each of the tank proximity variables with the model residuals. If there is a distance decay effect that our variables do not capture, we would expect the correlation coefficients to be significantly related to the error term. Each of the three correlations was found to be statistically insignificant, thereby indicating that our dummy variables for close proximity contain no error of measurement.

[2]We considered using the latitude and longitude to calculate distance and provide a measure of close proximity. However, we believe the accuracy of the GIS-generated geocoded coordinates to be accurate within 150 feet. This is not sufficiently precise for the task at hand.

[3]We attribute our inability to attain 100% accuracy in geocoding and PPN matches to two factors: random human error by others in recording site addresses, and incompleteness of the TIGER/Line files. This partially explains why we were unable to get all sites geocoded.

[4]Our matching technique is about 80% accurate. However, lots on the parcel maps do not always run consecutively, so we are likely to miss some sales that are near tanks, reducing our overall proportion to about 50%–60%. However, because we verified proximity using tax maps, we are certain that these remaining sales are in fact proximate to tank sites.

[5]The lead author, Robert Simons, Rudy Robinson and graduate student Stephen Crowther conducted these site visits during November and December 1994.

[6]The deletion of outliers increased the R^2 of the hedonic platform from .68 to over .76. We deleted cases in the top 0.1% which appeared to be largely attributable to human error. For example, this includes homes of over 9,000 square feet, lots with more than 800 feet of street frontage, and deeper than 2,000 feet. In general, deletion of these error outliers does not materially affect the results of our analysis of tank sites.

[7]The rooms and bedrooms variables were very highly correlated, indicating possible multicollinearity. We ran the model shown later in Exhibit 4 without number of rooms. The model had a slightly lower R^2, and results for the other variables were not significantly different. Scatterplots on all independent variables were acceptable, and did not exhibit any fanning that would require adjustment. We also examined the correlation matrix between rooms, bedrooms and building square footage and found no significant relationship between these variables and our three UST dummies. Thus, we find no reason for concern about the issue of multicollinearity in the model with respect to the statistical significance of our tank variables. TOL results also showed that the tank variables had almost no multicollinearity.

[8]The lot depth variable was significant in the linear model. However, in the Box–Cox transformation version its λ did not converge.

[9]The subgroup of sales near tank sites was similar to the overall population, but generally had about 10% more frontage, and an older, smaller house. Sales price was also slightly lower, at $80,400. Only 5% were duplexes.

[10]Although these numbers are small relative to the total number of sales, we are confident that all these sales were in fact proximate to the tank sites. Further, the nature of the toxic release for the *RGLK* group was more serious, with nearly half of those events having documented groundwater contamination or off-site effects, and an additional one third having soil contamination in excess of state-mandated action limits. In contrast, among the *LUST* group, most of the releases were small or moderate, resulting in soil contamination contained on-site: very few releases impacted the water table.

[11]We also ran an earlier model combining the *CLOSRGLK* and twenty-four *CLOSLUST* sales because we wanted to see if results were robust with a larger *N* related solely to proximity to leaky tank. The parameter estimate for this variable was reported to be −$8,032, and was statistically significant at $\alpha = .10$.

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