Toxic Sites and Housing Appreciation Rates: A Study of Market Adjustment

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August 2006

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Abstract

In many communities throughout the United States, contaminated sites are identified and addressed by the Environmental Protection Agency (EPA). In each of these communities, the EPA presents a plan of action and provides the community with information about progress being made. Does the housing market adjust quickly after announcements by EPA concerning the existence and toxicity of Superfund sites? Other studies have shown that the levels of house prices fall when people suspect there is a problem, and again when the EPA announces that the site is toxic (e.g. Kiel, 1995), but how can we tell when or if the market has completely adjusted to the existence of such a site? If the site is always perceived as an externality, then the coefficient on distance from the house to the site in the hedonic regression on house values should remain statistically significant and negative. Thus merely looking at the coefficient does not aid in determining when, or if, the market has cleared.

JEL Classification Codes: Q51, Q53, R2

Keywords: hedonic models, environmental prices, housing, adjustment time

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Toxic Sites and Housing Appreciation Rates: A Study of Market Adjustment

In many communities throughout the United States, contaminated sites are identified and addressed by the Environmental Protection Agency (EPA). In each of these communities, the EPA presents a plan of action and provides the community with information about progress being made. Does the housing market adjust quickly after announcements by EPA concerning the existence and toxicity of Superfund sites? Other studies have shown that the levels of house prices fall when people suspect there is a problem, and again when the EPA announces that the site is toxic (e.g. Kiel, 1995), but how can we tell when or if the market has completely adjusted to the existence of such a site? If the site is always perceived as an externality, then the coefficient on distance from the house to the site in the hedonic regression on house values should remain statistically significant and negative. Thus merely looking at the coefficient does not aid in determining when, or if, the market has cleared.

The market 'clearing' means that the discount due to the site is fully factored into the house prices. How can this be tested for? Evidence of a market that has cleared includes returns to the good being equal to returns in unaffected markets. Thus, one way of testing for market clearing is by looking at appreciation rates. Rates have been studied for houses near an energy generating incinerator and the researchers found that rates are statistically different (and are affected by distance from the incinerator) for at least 7 years after the plant has gone 'online' (Kiel and McClain, 1995b). In the case of a Superfund site, a federal agency is making announcements about the site, in particular the plans to make it 'safe' and when those plans have been enacted, so the housing market should adjust more quickly if individuals believe the agency’s statements.

This paper provides information on the speed of adjustment of the housing market in response to knowledge about the existence and safety of toxic waste sites. We expect that the adjustment will be faster than that seen in response to an incinerator, since the federal and state governments are involved in providing information to the public in the case of a Superfund site. However, it is possible that such sites are always perceived as undesirable, even after cleaning. This is referred to as “stigma” in the real estate literature. In the area studied in this paper, we find that the site is viewed as undesirable many years after cleanup has begun, but that the market has fully adjusted to the presence of the externality.

Literature Review

Several studies have measured the impact of undesirable land uses on house prices (e.g. Farber, 1998, Boyle and Kiel, 2001). Distance from the site, as well as changes in available information about the toxicity of the site affect property values. Since property value studies suggest that the impacts of the sites take place over long periods of time, it seems reasonable to expect that rates of appreciation are also affected. Greenberg and Hughes (1992) surveyed tax assessors in New Jersey, asking them their opinions of the impact of an EPA National Priority List site on local property values and appreciation rates. The respondents indicated that the presence of such sites lowered appreciation rates. Kiel and McClain (1995b) examined the effect of an incinerator on appreciation rates by studying rates calculated from repeat sales data and income capitalization models. They found that the rates are affected by distance from the site during both the construction and operation phases of the siting process, falling by between 2 and 3.5 percent on average.

The findings of Kiel and McClain (1995b) that the adjustment period to a new equilibrium could be quite long are supported by another study that examined the effect of a hazardous waste site in Dallas County on appreciation rates. McCluskey and Rausser (2003a), utilizing repeat sales data, found that residential property owners in close proximity to the hazardous waste site experienced lower housing appreciation rates after the time period when the EPA identified the site.

Changes in housing appreciation rates over time can yield information on the market adjustment process. In examining whether the market has adjusted to the presence of such a site, the coefficient on the distance from the site in the cross-sectional hedonic equation is not informative. If the site is always viewed as an externality, the coefficient will continue to be negative and statistically significant. Complete adjustment means that the value of the site is fully incorporated into the value of the house. However, it is possible to use information from appreciation rates to test for market adjustment.

Other methods have been utilized in order to assess the impact of a hazardous waste site on surrounding property values and warrant mentioning. Reichert (1997) advocated the use of an examination of liquidity in order to observe the arrival of a new equilibrium and to gauge the incorporation of information regarding the local disamenity into the price of the property. Housing in the area near an industrial landfill in Uniontown, Ohio was compared to housing in a control area similar but for its proximity to the hazardous waste site under examination. During periods of uncertainty and partial information, the length of time that houses were on the market in the subject area was substantially longer than in the control area. After some period of time, the length of time on the market in the subject area will again be equal to that in the control area. Reichert suggests that this indicates a new, and likely lower, market equilibrium has been established.

Two papers have addressed the issue of stigma in property values surrounding a lead smelter in Dallas County, Texas. McCluskey and Rausser (2003b) defined two externality effects that cause stigma. First is an environmental externality on the properties adjacent to a hazardous waste site, which causes neighboring property owners to be concerned about health issues. Second is a neighborhood externality, whereby the association with a hazardous waste site affects the composition of residents in the neighborhood and other attributes that determine neighborhood quality and property values. Some of these neighborhood changes may include social status, school quality, crime rates, police response, and the maintenance and tenure status of the houses. McCluskey and Rausser argue that if the neighborhood externality is the source of the stigma, then remediating the hazardous waste site may not result in increased property values. They find that the coefficient on distance, a crude test of the duration of stigma as mentioned earlier, changes significantly over the various time periods studied, representing a decrease in stigma related to the hazardous waste site.

In a second paper on the topic, Dale, Murdoch, Thayer, and Waddell (1999) do not make a theoretical distinction between temporary and long-term stigma. Furthermore, the authors found that there was no long-term stigma associated with the hazardous waste site in Dallas County following remediation. One key difference between the papers by McCluskey and Rausser (2003b) and Dale, Murdoch, Thayer, and Waddell (1999) is in the final time period studied, during which additional unfavorable information regarding the state of the site following cleanup was released. Dale, Murdoch, Thayer, and Waddell (1999) find that there was no significant reaction on the distance variable with the release of the information. McCluskey and Rausser (2003b) find that the coefficient on the distance variable rose again as unfavorable information was released, signifying a possible stigmatic response to information about the hazardous waste site.

Data

This research examines the town of Woburn, Massachusetts, a suburb of Boston. It has an area of 12.9 square miles, and a population in 1990 of 35,943 and in 2000 of 37,258 for a growth rate of 3.2% compared to Massachusetts as a whole which grew at 5.5% over the same time period. There is one school system in the town and 6.1% of the population was below the poverty rate. The median house value in 2000 was $218,600 and 61.2% of the population owned their homes.[1]

There are two Superfund sites in the city: Industri-Plex and Wells G and H (see Figure 1). Industrial activity began at the former site in 1853, while the wells were developed in 1964 and 1967. In the late 1970s, development activity at the Industri-Plex site led to a release of odors. The odors were caused by the materials buried by the tanneries that had previously owned the properties. The site was tested for toxicity in 1979, and the wells were closed at that time. In late 1980, the first federal response was undertaken. In early 1981, Senator Edward Kennedy toured the site, and held hearings on the Superfund sites. The sites were proposed to be placed on the National Priorities List in October 1981, and were officially placed on the list in September 1983. The sites were to be cleaned in the late 1980s, but the cleaning process did not begin until 1992-93. A permeable cap was built over the site with construction completed as of 1997. Several developments have been completed at the site with a shopping center, a highway interchange, and a transportation center all completed in the early 2000s. A final remedy was

[1] Information from Massachusetts Municipal Profiles and the U.S. Census website.

selected on January 31, 2006.

The community was actively involved in the process of mitigating the pollution. In 1980 a citizen group was formed to interact with the various government agencies involved in the process. Thus information on the site and its future was made available to the public from the various agencies and from the citizens' groups.

The data set used to test whether the housing market in Woburn adjusted fully to the Superfund sites consists of all single family home sales from January 1975 though December 2002. These data were obtained from the Woburn Assessor's Office, the Middlesex Registry of Deeds, from Banker and Tradesman, and from the Warren Group. Observations were eliminated if the owner's address was not the same as the location of the house, if there was an in-law apartment, or if the transaction was not 'arm's length.' In addition to the physical characteristics of the house, information on the distance from the house to each of the sites was added using U.S. Census Bureau Tiger 4 files and Mapinfo. There are 4,431 observations in the final data set. Means, standard deviations, and variable descriptions are available in Table 1.

Empirical Results

We first examine the impact of the Superfund site on local home prices over time. Following the framework of Kiel (1995), we estimate the following hedonic regression:

$$
\begin{aligned}
Ln(\mathrm{Pr}\,ice) &= \beta_0 + \beta_1 Age + \beta_2 Agesq + \beta_3 Area + \\
&\beta_4 Style + \beta_5 Defl + \beta_6 Ln(dist) + \in_i
\end{aligned}
$$

where Style is a dummy variable for one of four house styles: cape, colonial, ranch, or split level. Defl is the median sales prices of existing family homes for the Boston metropolitan area in the year in which the house sold, as published by the National Association of Realtors. The log of the distance from the nearest Superfund site to the house is also included.

The regression is estimated for eight time periods. The first is 1975-76 which is prior to any announcements by the U.S. EPA. The second is 1977-81 which is the period of time that the pollution was first discovered and brought to the attention of the EPA. The third is 1982-84 which is the EPA announcement phase; followed by 1985-88 which is when the first cleanup plan for the Industri-Plex site was announced. The fifth period is 1898-91 when the first cleanup plan for the Wells was announced. In 1992-95 cleanup began; in 1996-98 the EPA undertook its final investigation; in 1999-2002 development of the area began.

Table 2 contains examples of the regressions for all eight periods. The coefficients have the expected sign and the adjusted R^2 is relatively high for cross-sectional data. The coefficient on the distance from the site is positive and is statistically significant in five of the eight regressions. The lack of statistical significance in the first period suggests that home buyers did not perceive the area as an undesirable neighbor prior to the discovery of the pollution. The significance of the coefficient in the final period indicates that individuals in that period perceived the location as undesirable even though cleaning and development were well underway.

Table 3 calculates the marginal benefit of increased distance from the Superfund site. As a percentage of price, the largest impact is in the final period. This suggests that individuals continue to perceive the site as a negative externality; it would appear that there is some stigma attached to the site itself. The Woburn site may be unusual in this regard. This site was the focus of a book (“A Civil Action”) and a movie by the same name so one might expect that most home buyers would know about the existence of the site. Other, less publicized sites, might not maintain a stigma after the EPA has begun the process of cleaning up the site (Kiel and Williams, 2006).

In order to test whether or not the market has fully adjusted to the externality, we examine the appreciation rates of houses in the area. Following Kiel and McClain (1995b), house values are assumed to follow:

$$V(t) = \int_T^{\infty} R_0 e^{\alpha t} e^{\sum_i \mu_i DUM_i t} e^{-rt} dt$$

where R is the rental value, α is the rate at which values appreciate, μi is the appreciation rate during each of the eight periods in which we observe house prices, DUM_i is a dummy variable for each of the periods, and r is the discount rate. Taking the integral we obtain:

$$V(t) = \frac{R_o e^{-(r-\alpha-\sum_i \mu_i DUM_i)T}}{r-\alpha-\sum_i \mu_i DUM_i}$$

After taking the logs of both sides we obtain:

$$\ln V(t) = \ln R_0 - (r-\alpha)T + \sum_i \mu_i DUM_i T - \ln(r-\alpha-\sum_i \mu_i DUM_i)$$

This equation is then estimated for the entire data set. The dependent variable is the log of the ratio of the sales price over the median sales price of a single family home in Boston in the relevant year. Included as explanatory variables are house characteristics including distance to the site, a time trend, and indicator variables of the period in which the house sold interacted with the time trend. If the estimated coefficients on the interaction terms are zero, this will suggest that appreciation rates are constant across those periods. This will be taken as evidence that the housing market in that area has adjusted to a new equilibrium.

The regression results are in Table 4. The estimated coefficients on those characteristics that impact the rental value all have the expected sign and are statistically significant. The coefficient on the time trend (T) which captures both the Woburn appreciation rate and the discount rate is not statistically significant. The period dummy variables allow for changes in the trend and move with changes in the housing market in Woburn.

The coefficients of interest are the period dummy variables interacted with the time trend. Notice that all but two of these coefficients are not statistically different from zero. The market appears to not be in equilibrium in the period when pollution was first discovered and brought to the attention of the EPA, nor in the period when the first cleanup plan for the Industri-Plex site was announced. However, since 1989 the market has adjusted to a new equilibrium and has done so fairly quickly. This would suggest that information about the existence of the site and its risks is readily available to home purchasers. Individuals who purchase in this market will pay a lower price for homes close to the Superfund site, but the rate at which their home will appreciate will not be impacted. Again, the Woburn area may be unique in this regard. Other Superfund sites may not see as rapid an adjustment to the information released by the EPA and the community; only studies of those sites would resolve that question.

Conclusions

When an undesirable land use is discovered in a community, house values react. Over time, once all information is available, the market should adjust to the site. However, researchers cannot tell when the adjustment is complete by looking at hedonic regressions; the coefficient on distance to the site can remain statistically significant after the adjustment process is finished. One needs to look at the rate at which house prices change over time in order to determine whether or not the market has finished adjusting to the site.

In this paper the housing market in Woburn, Massachusetts and its response to the discovery of two Superfund sites is studied. The results examining the appreciation rates suggest that the housing market in Woburn has adjusted to the site which is not surprising given the length of time that has passed since the initial discovery of the site. In examining the hedonic regressions we can see that house prices are lower for those houses closer to the site, all else held constant. This suggests that there is on-going stigma surrounding the site even though it has been cleaned and re-developed.

Studies of this type can be used to test for market clearing in response to other undesirable sites. The results can assist assessors in predicting future impacts on property values, and can aid those designing compensation packages. It appears that the market adjusts fairly quickly to such sites, but that the decline in values will be present as long as individuals view the sites as negative externalities.

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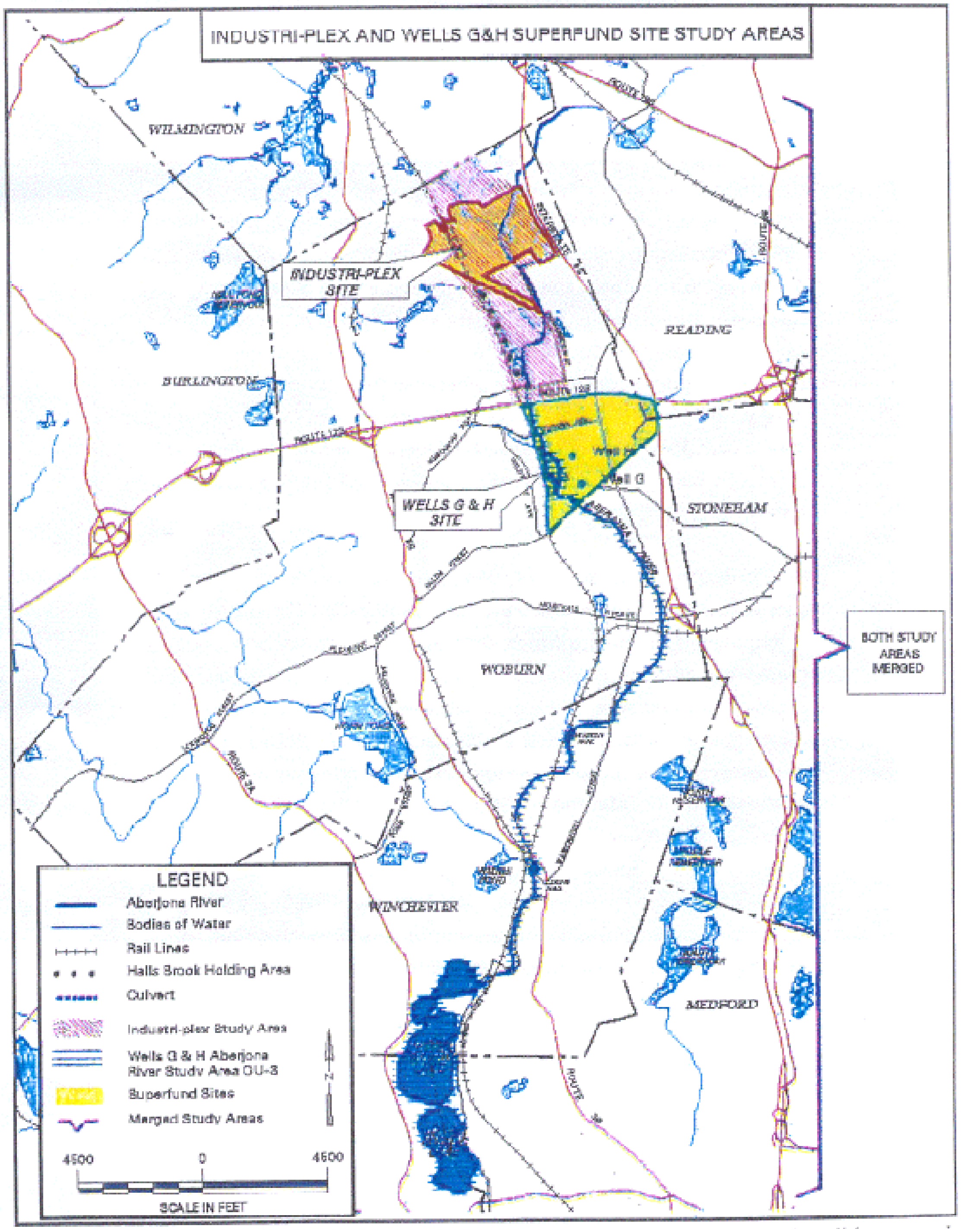
Figure 1
Area Map



Map courtesy of United States Environmental Protection Agency

Table 1
Variable Names and Descriptive Statistics

Variable Name	Description	Mean (Std Dev)
PRICE	Sales price of house in nominal dollars	163743.25 (83532.90)
LANDSQFT	Total property area in square feet	12113.40 (6878.04)
AGE	Date of Sale - year built	46.95 (38.17)
AGEDQ	AGE squared	1220 (4214)
BEDS	number of bedrooms	3.09 (0.76)
BATHS	number of bathrooms	1.462 (0.56)
DIST	distance from house to Industri-Plex in miles	1.697 (0.96)

Sample size is 4,431.
Standard deviations in parentheses.

Table 2
Regression Results

Variable	1975-1976	1977-1981	1982-1984	1985-1988	1989-1991	1992-1995	1996-1998	1999-2002
Constant	10.3314	9.133	10.133	10.075	10.180	11.395	11.176	11.130
	(19.778)	(78.462)	(98.967)	(77.118)	(39.421)	(63.795)	(100.823)	(126.607)
Age	-0.0042	-0.0053	-0.0063	-0.0028	-0.00485	-0.0045	-0.0035	-0.0054
	(2.475)	(5.020)	(5.076)	(2.706)	(6.152)	(8.090)	(3.582)	(6.971)
Agesqd	1.70E-05	2.42E-05	3.76E-05	1.17E-05	2.10E-05	1.29E-05	1.15E-05	1.60E-05
	(2.332)	(3.728)	(3.965)	(1.90)	(3.650)	(4.468)	(2.253)	(4.145)
Area	0.000155	0.000153	0.000116	0.000162	0.000157	0.00014	0.000254	0.00025
	(6.173)	(5.379)	(4.427)	(4.715)	(5.276)	(4.288)	(10.254)	(11.059)
Cape	-0.03704	0.0510	-0.0013	0.02727	0.02713	-0.0557	0.0130	-0.0154
	(0.575)	(1.210)	(0.372)	(0.633)	(0.860)	(2.40)	(0.4902)	(0.4112)
Colonial	0.0156	0.0611	0.0033	0.0739	0.0507	-0.0196	-0.03661	-0.0138
	(0.208)	(1.289)	(0.075)	(1.564)	(1.282)	(0.738)	(0.8415)	(0.3095)
Ranch	0.0855	0.1305	0.0370	0.0719	0.0530	-0.0131	0.0395	0.02775
	(1.162)	(2.908)	(1.075)	(1.830)	(1.755)	(0.493)	(1.355)	(0.7041)
Spltlvl	0.0608	0.2327	0.2218	0.1069	0.1215	0.0635	0.0379	0.1444
	(0.828)	(3.616)	(3.07)	(1.295)	(2.842)	(1.929)	(0.6095)	(3.164)
Defl	-3.1E-07	2.19E-05	1.18E-05	9.61E-06	1.03E-05	2.83E-06	3.04E-06	3.69E-06
	(0.029)	(18.18.)	(12.088)	(13.20)	(7.005)	(2.447)	(5.977)	(15.646)
LnDist	0.0241	0.0535	0.0259	0.0497	0.0380	0.0453	0.0237	0.09575
	(0.935)	(3.314)	(1.838)	(2.594)	(3.040)	(3.975)	(1.731)	(5.3779)
N	105	402	355	676	458	743	642	1081
Adj R^2	0.5116	0.6290	0.4958	0.3805	0.4207	0.3446	0.3400	0.3804

NOTES:
The dependant variable is the natural log of the house's sale price.
Numbers in parentheses are the absolute value of the t-statistics which are significant at the 5-percent level if greater than or equal to 1.96.
White Standard errors.

TABLE 3
Marginal Benefit of Increased Distance from NPL Site

Time Period	Mean of LNPRICE	Mean of Price	Coefficient on LNDIST	Mean Distance From Site	Marginal Benefit Per Added Mile	% Marginal Benefit Per Added Mile
1975-1976	10.49172	36646.85	0.0241	1.781821378	495.6665243	1.352548595
1977-1981	10.775	50015.58	0.0535	1.677163839	1595.45157	3.189908985
1982-1984	11.24313	78413.79	0.0259	1.729585179	1174.222159	1.497468891
1985-1988	11.89972	153781.13	0.0497	1.654134527	4620.496242	3.004592383
1989-1991	11.95427	158796.90	0.0380	1.709000393	3530.884059	2.223522017
1992-1995	11.89455	150732.29	0.0453	1.72793984	3951.626423	2.621619049
1996-1998	12.01721	171076.52	0.0237	1.710874992	2369.847871	1.385256089
1999-2002	12.40294	258801.10	0.09575	1.696731651	14604.66948	5.643202325

Table 4

Dependent Variable: LNPBI2

Included observations: 4462 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic
C	-0.537156	0.050108	-10.72003
AGE	-0.004285	0.000277	-15.47350
AGESQD	1.33E-05	1.73E-06	7.670877
AREA	0.000132	1.21E-05	10.90619
LOTSIZE	4.30E-06	7.14E-07	6.022341
BEDS	0.013831	0.006205	2.229155
BATHS	0.050094	0.008005	6.257829
LNDIST	0.020980	0.024395	0.860039
LNDIST7781	0.033373	0.029528	1.130199
LNDIST8284	-0.007481	0.027857	-0.268570
LNDIST8588	0.017932	0.030792	0.582377
LNDIST8991	0.010753	0.027198	0.395364
LNDIST9295	0.015216	0.026609	0.571848
LNDIST9698	0.001832	0.027679	0.066188
LNDIST9902	0.076451	0.029556	2.586622
D7781	-0.258441	0.056166	-4.601374
D8284	0.021170	0.116088	0.182365
D8588	-0.496995	0.144736	-3.433800
D8991	0.701813	0.150666	4.658073
D9295	0.506186	0.126916	3.988349
D9698	1.098783	0.229794	4.781604
D9902	-0.226888	0.217828	-1.041592
T	-0.024542	0.025409	-0.965847
T7781	0.070029	0.026338	2.658889
T8284	0.037762	0.027979	1.349658
T8588	0.078017	0.027493	2.837679
T8991	-0.001220	0.027014	-0.045146
T9295	0.009316	0.026128	0.356559
T9698	-0.014923	0.027271	-0.547210
T9902	0.037962	0.026556	1.429482

R-squared	0.373256	Mean dependent var	-0.151859
Adjusted R-squared	0.369155	S.D. dependent var	0.285944
S.E. of regression	0.227113	Sum squared resid	228.6035
F-statistic	91.01627	Prob(F-statistic)	0.000000