W.R. Grace Acton Site Clean Up

Report from

Lin & Hutton Co.

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Executive Summary

- In 2006 under the Remedial Design/Remedial Action Statement of Work, you have agreed to pay $18 million (*$20,216,160 in 2011 dollars**) to clean up the Acton site
- A group of activists using 1980 data claims that a more aggressive and thorough clean up is needed and will require in excess of $400 million (*$1,099,131,000 in 2011 dollars**)
- We estimate that a complete cleanup that will provide the *greatest benefit* to nearby residents will actually cost $170 million *($468,763,971 in 2011 dollars**)

*2006 and 1980 dollars converted to 2011 dollars via usinflationcalculator.com

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Executive Summary

- We arrived at our estimates by using a hedonic regression to isolate the effect of distance from the Acton site on the sale price of homes
- The variables we isolated to determine the value of the homes are more highly correlated and better fitted to house price than the variables used by the activists
- Therefore, we believe our estimate provides a more realistic picture of the true benefits to residents from a complete clean up

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Background

- To determine the willingness to pay for a cleanup of the Acton site, environmental activists used data collected by David Harrison that consisted of observations on characteristics of 2182 houses and distance from ten hazardous waste sites
- Our first step was to replicate the method the activists used to claim that complete clean up of the Action site would be in excess of $400 million in 1980 dollars

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Analysis of the Activists' Approach

- In replicating the activists method, we found that the variables chosen to determine house price did not accurately assess the structural, neighborhood, accessibility, and air pollution characteristics of a house and the surrounding environment that correlate to a home's value
- Therefore, we started from a clean slate and used the Harrison data to develop a better pricing model

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We agree with the high level methodology used by the Activists, but do not agree with the way certain variables were used in the model. The Activists' approach to assess house prices with or without damages was flawed particularly for the way distance variable was used in the estimate. We will explain in more details in the next few slides how we believe the distance variable from Acton should be addressed.

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- To conduct our analysis, we first isolated the 90 observations for which the homes are closer to the Acton site than to other sites
- We believed this data set would allow us to build a stronger model to assess expected price of homes more directly affected by the Acton site and no other site

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Lin & Hutton Co. Analysis

- Distance to Acton site was used linearly in the Activist's approach
- The assumption was made that pollution effect was nonexistent beyond 10 miles from Acton site
- With distance variable applied linearly in the equation, results are directionally correct, however it does not provide best fit to data
- The Activists' approach is particularly flawed when distance is set to 10 to calculate expected price without hazard, as the equation does not mathematically reflect nonexistent pollution effect at 10 miles

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Lin & Hutton Co. Analysis

- Our approach uses a transformed distance variable, where we used (10-distance)^2
- This mathematically transforms the distance and is consistent with assumption that at 10 miles, effect of Acton site pollution is non-existent
- Also provides better fit to data with exponent of 2.
  - Reference: Harrison and Rubinfeld (1978), "He-donic Housing Prices and the Demand for Clean Air," Journal of Environmental Economic Management 5, 81–102.
- Used data from 90 houses closest to Acton site to develop model.

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Quadratic relationship in model for distance variable also ensures that distance variable has largest impact on house prices with or without damages, which are believed to be realistic when holding other attributes constant.

Because we assume that if a house is ten or more miles from Acton, then the pollutant is gone, the expected price of a house calculated from the hedonic regression with distance set to ten miles and all other values set to those in the data gives the expected price of the house were the pollutant gone.

Data Variables for Assessing Hazard

- From our analysis, we believe that to determine the value of a house impacted by the pollution of the Acton site, one must consider the following components:

Distance from W.R. Grace Acton Site	Lot size
Year and month sold	Living area in the house
Year the house was built	Nitrogen oxide concentration
Forced air heat	Access to radial highways
Hot water heat	Pool
Number of fire places	Full value of property tax rate
Covered parking	Pupil to teacher ratio

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In addition to transforming distance from Acton site, we also transformed Nox content by multiplying by 100 then squared to provide a strong correlation to house prices. Reference: Harrison and Rubinfeld (1978), "Hedonic Housing Prices and the Demand for Clean Air," Journal of Environmental Economic Management 5, 81–102.

Lin & Hutton Co. Analysis

- Similar to the Activists, we assumed that if a house is ten or more miles from Acton, then the pollutant is gone
- The expected price of a house calculated from the hedonic regression with distance set to ten miles and all other values set to those in the data gives the expected price of the house where the pollutant is gone
- When distance is set to 10, our transformed distance term in the model becomes 0, effectively removing the impact of Acton site pollution on house prices

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Data Variables for Assessing No Hazard

- Same model as assessing house prices with hazard, except distance term (Acton effect) is 0.

~~Distance from W.R. Grace-Acton Site~~	Lot size
Year and month sold	Living area in the house
Year the house was built	Nitrogen oxide concentration
Forced air heat	Access to radial highways
Hot water heat	Pool
Number of fire places	Full value of property tax rate
Covered parking	Pupil to teacher ratio

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Total Damage

- With a formula/model to determine expected prices with and without hazard, we then determined the total cost of damage (delta between the two) for homes impacted by the pollutants from the Acton site.
- We used the 182 observations in the Harrison data set that are within ten miles of Acton to calculate expected prices under the assumption that homes within 10 miles of Acton are affected by the pollutants.

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Total Damage

- We arrived at an average damage value of $2,666 (in 1980 dollars) per home within ten miles of Acton, equivalent to $7,325* in 2011 dollars.
- The activists' claim that there are approximately 64,000 homes within the 10 miles radius of Acton
- Taking this assumption into account, the total estimated damage is $170,594,385, equivalent to $468,763,971* in 2011 dollars.

*1980 dollars converted to 2011 dollars via usinflationcalculator.com

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Additional Considerations

- With our analysis, we focused on the 182 houses within 10 miles of Acton
- If the data is available, we recommend additional analysis of the houses within the 182 data set that might also be impacted by pollutants from one of the other 10 hazardous sites
- A more accurate estimate of total damage could be determined by taking into account overlapping damage from other sites in addition to Acton

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Final Remarks/Conclusion

- By using more reasonable approach and data variables, we came up with a better fitted model than the Activists (~ 2.4 times less in total damage).
- Specific comparison:

	Our Analysis	Activist's Analysis
Per house damage in 1980 dollars	$2,666	$6,430
Per house damage in 2011 dollars	$7,325	$17,668
Total damage in 1980 dollars	$170,594,385	$411,520,000
Total damage in 2011 dollars	$468,763,971	$1,130,786,040

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Appendix

Variable Definitions/Units:

dista1: distance to W.R. Grace Acton, miles (transformed to (10-dista1)^2)	**nheatf**: dummy variable = 1 for forced air heat
ln3: lot size (log square feet)	**nheath**: dummy variable = 1 for hot water heat
ln8: living area in house (log square feet)	**yrblt**: year the house was built
lnoxo: nitrogen oxide concentration, parts per million (transformed to (lnoxo *100)^2)	**yrmo**: year and month sold
lrad: log of index of access to radial highways	**n36**: Number of fire places
n35: dummy variable = 1 if pool; 0 otherwise	**n37**: dummy variable = 1 if covered parking
n40: full value property tax rate	**n41**: pupil to teacher ratio

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Appendix

Regression analysis criteria

The following criteria were used to determine the best regression models:

- **P Value**: In general, you want p-values less than 0.05 since 1-P value is confidence that slope is not 0
- **T-stat**: In general, you want t-stats greater than 2 in absolute value since this represents how many standard errors away from 0
- **R^2**: A higher R^2 means a lower fraction of variance; R^2 goes up when standard error goes down
- **Correlation**: Values close to -1 or 1 indicate high correlation
- **Multicollinearity**: Values away from 0 may indicate multicollinearity or that you may be using more variables than necessary; redundancy
- **Residual Stats**: Autocorrelations should be close to 0
- **Residual Plot**: Histogram of residuals should look like a normal distribution, bell curve

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Appendix

Hedonic regression equation for expected price with hazard:

Price = exp (1.2219 - 0.0015 _10_dista1_2 + 0.0478 ln3_ + 0.5671 ln8_ + 0.4788 lrad - 0.1135 n35_ + 0.0592 n36_ + 0.1322 n37_ + 0.0124 n40_ - 0.0233 n41_ - 0.1724 nheatf - 0.1514 nheath + 0.6811 NOx2_ + 0.0055 yrblt - 0.0007 yrmo)

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_10_dista1_2 = (10-dista1)^2
NOx2 = (lnoxo*100)^2

Most variables along with coefficients make sense (positive or negative relationships match intuition and common beliefs). An unusual relationship is NOx level, where the coefficient indicates higher Nox correlates to higher house prices which is counter-intuitive. However, taking a closer look at data reveals that most houses with higher NOx happen to be located further from Acton, therefore resulting in the positive correlation. This confirms that Acton site effect outweighs other factors and possibly indicate that Acton site is located in comparably lower NOx concentration region.

Appendix

Hedonic regression equation for expected price without hazard:

Price = exp (1.2219 + 0.0478 ln3_ + 0.5671 ln8_ + 0.4788 lrad - 0.1135 n35_ + 0.0592 n36_ + 0.1322 n37_ + 0.0124 n40_ - 0.0233 n41_ - 0.1724 nheatf - 0.1514 nheath + 0.6811 NOx2_ + 0.0055 yrblt - 0.0007 yrmo)

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FSBstats Regression Statistics

Regression Statistics

R Square	Adj.RSqr	Std.Err.Reg.	# Cases	# Missing	t(2.5%,75)
0.893	0.873	0.122	90	0	1.992

Summary Table

Variable	Coeff	Std.Err.	t-Stat.	P-value	Lower95%	Upper95%
Intercept	1.222	2.805	0.436	0.664	-4.366	6.809
_10_dista1_2	-0.001	0.001	-2.036	0.045	-0.003	0.000
ln3_	0.048	0.017	2.791	0.007	0.014	0.082
ln8_	0.567	0.045	12.619	0.000	0.478	0.657
lrad	0.479	0.132	3.619	0.001	0.215	0.742
n35_	-0.114	0.053	-2.148	0.035	-0.219	-0.008
n36_	0.059	0.026	2.284	0.025	0.008	0.111
n37_	0.132	0.039	3.381	0.001	0.054	0.210
n40_	0.012	0.002	5.439	0.000	0.008	0.017
n41_	-0.023	0.006	-3.774	0.000	-0.036	-0.011
nheatf	-0.172	0.054	-3.194	0.002	-0.280	-0.065
nheath	-0.151	0.054	-2.808	0.006	-0.259	-0.044
NOx2_	0.681	0.120	5.679	0.000	0.442	0.920
yrblt	0.006	0.001	5.588	0.000	0.004	0.007
yrmo	-0.001	0.000	-2.903	0.005	-0.001	0.000

Good p-values, better R2.

Activist's Model FSBstats Regression Statistics

Regression Statistics

R Square	Adj.RSqr	Std.Err.Reg.	# Cases	# Missing	t(2.5%,81)
0.832	0.815	0.148	90	0	1.990

Summary Table

Variable	Coeff	Std.Err.	t-Stat.	P-value	Lower95%	Upper95%
Intercept	-16.301	4.023	-4.052	0.000	-24.306	-8.296
dista1	0.020	0.010	1.984	0.051	0.000	0.040
ln3_	0.035	0.020	1.770	0.080	-0.004	0.075
ln8_	0.661	0.050	13.319	0.000	0.563	0.760
lnoxo	548.228	105.019	5.220	0.000	339.274	757.183
lrad	0.625	0.146	4.296	0.000	0.336	0.915
n40_	0.013	0.003	5.015	0.000	0.008	0.019
n41_	-0.023	0.007	-3.132	0.002	-0.037	-0.008
yrblt	0.006	0.001	6.345	0.000	0.004	0.008

Not so good p-values for dista1 (further proves weak fit), and ln3.
R square not as good as ours.