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Application of Repeat Sales Analysis to Determine the Impact of a Contamination Event

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Abstract

Prior studies of environmental contamination examine the cross-sectional impacts, either through a sales-comparison-type model or hedonic pricing. Neither model is robust at analyzing the impact of an event, such as a contamination announcement. Longer term longitudinal studies may not control for exogenous impacts, such as changes in house quality. This study uses a repeat-sales index to extract value-trend changes immediately after a contamination announcement, thus isolating the impacts of the event itself and controlling for exogenous factors. While the study is focused on contamination, it is generalizable to any systemic event.

Common real estate valuation methodology most often measures the impact of stigma through some type of cross-sectional analysis. For example, traditional sales adjustment grid analyses apply stigma as an adjustment determined through some sort of matched pairs or other location adjustment. Hedonic modeling or other mass appraisal techniques, preferred when large data sets are available, use data from both within and without a contaminated area and a dummy variable to capture the effect of stigma on value. When distance to a point-source of contamination is a factor, then some sort of spatial analysis or distance function is included in the hedonic pricing model.

All of these methods implicitly assume that markets have fully captured information about the contamination and that stigma impacts are fully reflected in prices. However, Simons (2002) illustrates the time problem associated with a contamination announcement. Four interlocked trends are manifested longitudinally:

1. It often takes a period of years for information about contamination to be fully diffused in a market place.
2. In the short run, buyers often have few alternatives, resulting in disequilibrium from this truncated supply.
3. In the short run, sellers have reservation prices, often as a result of outstanding liens, mortgage loans, and selling costs, below which they cannot transact a sale. Kinnard (1992) observes that this would suggest that there was more information in sales which did not occur than in sales which did.
4. In the long run, buyers find alternatives and sellers reduce their reservation prices (at least in real terms). As such, long-term price trends are either reduced, compared to otherwise unaffected properties, or actually negative in real terms for a period of time until a new equilibrium emerges at a lower range of values.

When a market-dislocating contamination announcement or event occurs, an event-study methodology should be more illuminating about market behavior than a cross-sectional study. While the real estate finance field is replete with the appropriate methodologies necessary, prior studies have yet to apply these methodologies to contamination events or analyses.

This study examines those methods and uses data from a recent water contamination case to illustrate the usefulness of repeat sales analyses. The affected neighborhood is in California, which has robust and thorough disclosure requirements for matters such as these. Prior studies and appraisal methodology used changes in rates-of-return exclusively to analyze stigma in income producing property. The study illustrates how stigma is manifested in changing residential return rates over time and how changes in those return rates impact residential property values.

The remainder of this paper is organized as follows: Section 2 reviews the salient literature, including the fundamental mechanisms by which contamination affects property values, as well as the support for the methods used in this study. Section 3 leverages off of the methodological literature to develop an empirical model, and uses the fundamental contamination literature to develop a testable hypothesis concerning the impact of a contamination event on transaction prices in a neighborhood. Section 4 applies this model to a recent transaction data set from Santa Clara County, California. The final section summarizes the results and offers suggestions for further research.

Prior Research

Fundamentals of Stigma Analysis

Patchin (1992) was one of the first to note that the decline in market value of a contaminated property may exceed the cost to cure, even when that cost to cure is well defined. Mundy (1992a) builds on this theme and is one of the first to outline the value paradigm for appraisers to estimate contaminated property damages. He ascribes the paradox observed by Patchin as the "stigma" effect. In Mundy's (1992a) framework, stigma is directly related to the level of uncertainty or risk associated with the contamination. His methodology was later incorporated into the Uniform Standards for Professional Appraisal Practice (USPAP) via USPAP Advisory Opinion 9.

Mundy (1992b) follows this theme by outlining what is now a widely recognized valuation approach with two components: an income effect and a marketability effect. In the case of residential properties, the income effect measures the loss of use and enjoyment. The marketability effect accounts for the losses stemming from expected additional time-on-the-market, either to rent or to sell, as well as the diminished expected value at sale. Mundy (1992c) continues this theme, exploring the quantification of stigma as it impacts the cost of capital (borrowing costs, for residential) and, for non-residential properties, the indicated discount rate on equity.

Empirical Stigma Studies

To date, most empirical studies into stigma and residential diminution focus primarily on cross-sectional models, either using simple appraisal techniques (e.g., sales adjustment grid) or some variation on hedonic pricing. For example, in one of the earliest empirical studies into the impact of contamination on residential values, Gamble and Downing (1982) examined the impact of the March 1979, nuclear accident at Three Mile Island on nearby home values. They compared 583 residences within 25 miles of the plant with homes in a control neighborhood 75 miles away, both before and after the accident occurred using a hedonic model to isolate the pricing impacts of the event.

Edelstein (1988) specifically stresses the investment diminution aspect of the inversion of home principle. In citing case studies of experiences following neighborhood-wide impairment in the Legler section of Jackson Township in southern New Jersey, he shows that residents could not separate the psychological pride in home ownership from the question of economic value. Surveys of the population found uniformity of opinion that property values had diminished as a result of the problem. Previous studies had focused on the opportunity costs stemming from the inability to move. In short, homeowners were stuck holding unsellable property with stagnant prices, while property in other neighborhoods was soaring in value. Thus, the owners were harmed not only by the diminution of value in the existing residences, but by the opportunity costs inherent in lost gains from alternative home investments.

Abdalla, Roach, and Epp (1992) examined data on the averting expenditures that homeowners must incur when dealing with a groundwater contamination incident involving TCE. The economic costs to households to deal with the contamination of their groundwater ranged from $61,313 to $131,344 during an 88-week contamination period. The authors also found that the decision to incur averting expenditures was based on the knowledge of the contamination, the degree of risk perceived, and the presence of children in the household.

Page and Rabinowitz (1993) discuss the impact of groundwater contaminated with toxic chemicals on the value of both contaminated and surrounding property. They find that groundwater contamination negatively affects industrial and commercial properties. However, their research also indicates that residential real estate markets do not function properly, due to the failure of buyers to react to information flows. They find three disconnects in value perceptions by homeowners:

- Property owners failed to perceive the risks associated with the ownership of property near toxic contamination.
- Property owners often are not informed and buyers are not aware of the contamination. Real estate agents and brokers avoid discussing environmental issues with prospective buyers and residential appraisers often fail to address the issue of hazardous materials or contamination, even though fair-market-value presumes a knowledgeable, prudent buyer.
- Due to the high value society places on ownership, buyers feel protected from contamination problems, again failing the "knowledgeable, prudent buyer" test.

Kiel (1995) used a cross-sectional hedonic model to examine the effects on housing values in Woburn, Massachusetts, a community with two Superfund sites, one a source of TCE groundwater contamination. Both sites were identified as Superfund sites in the early 1980s, and the clean-up process had begun by 1995. She reviewed values of over 2,000 houses over the period 1975 to 1992, utilizing regression techniques with specified time periods: pre-announcement phase, discovery phase, announcement phase, and clean-up-identified phase. She also analyzed impacts of distance from the sites and discounted values of future rents, which would be earned on the residences. Bible, Hsieh, Joiner, and Voluntine (2002) follow in the same vein as Kiel (1995) looking at distance from a point-source to study the impact of creosote contamination on surrounding home values.

The widespread use of cross-sectional hedonic models to estimate residential stigma resulting from contamination is well summarized in Boyle and Kiel (2001).

Repeat Sales Indices

Case and Shiller (1990) point out that cross-sectional models are less useful at extracting information about residential price movements over time. As a result, real estate price indices typically build on the seminal work of Bailey, Muth, and Nourse (1963), who observe that repeat sales time-series forecasting is superior to cross-sectional regression for such matters.

Pollakowski (1995), Stephens, et al. (1995), and Wang and Zorn (1997) describe the repeat sales housing price index. Goetzmann and Spiegel (1995) note that house price appreciation over time consists of both temporal components and non-temporal components, such as home quality changes. Hence, a simple index of house prices over time fails to control for these non-temporal components. Pollakowski and Ray (1997) show that the repeat sales method is superior to regression for controlling for these non-temporal components, and they demonstrate the construction of an index and the extraction of average quarterly returns.

Clapp and Giaccotto (2002) study repeat sales-based forecasts and find that "[T]he repeat sales method performs better than the hedonic in terms of some basic, descriptive statistics: repeat PE's have lower means, skewness, and kurtosis." Clapp and Giaccotto analyze repeat sales from the Miami-Dade County area from 1971 through the first half of 1997 (a total of 5,159 homes that sold twice). They found that the repeat sales method had a mean error rate of 0.5% compared to a mean error rate of 0.9% for the hedonic (cross-sectional) model. Today, the use of repeat sales methods for creating house price indices is nearly universally recognized.

To quote, Clapham, Englund, Quigley, and Redfern (2004): "In the United States, the only widely available set of quality-controlled housing price indices are based on so-called repeat sales models."

Similarly to Pollakowski and Ray (1997), Baroni, Barthellemy, and Mokrane (2005) develop a basic equation of periodic rates of return, extracting periodic rates from an overall repeat sales index, in a multi-year study of apartment prices in Paris. Similar methods are proffered in by Stephens, Li, Lekkas, Abrham, Calhous, and Kimner (1995), Wang and Zorn (1997), Reinsdorf, Diewert, and Ehemann (2002), and McMillen (2002). Pennington-Cross (2003) notes that many of the more popular repeat-sales indices aggregate prices over a large area (e.g., National Association of Realtor indices for large metropolitan areas). He investigates the potential for aggregation bias in repeat sales indices across larger geographic areas and finds no empirical evidence of a size-induced bias.

Event Studies

Methodology for an event study has been a part of the financial economics toolbox for many years, and was rigorously summarized and restated by Khotari and Warner (2005). A good starting point for a discussion of event studies is Brown and Warner (1980), who test methodologies using mean-adjusted prices, market-adjusted prices, and risk-adjusted prices. Brown and Warner (1985) extended this research, and employed an OLS-developed market model to calculate abnormal returns for assets, using security prices, as shown in Equation 1:

$$AR_{i,t} = R_{i,t} - \alpha_i - \beta_i(R_{m,t}). \tag{1}$$

Where: AR = Abnormal return for asset i for time t;
$R_{i,t}$ = Actual return for asset i during time t; and
$R_{m,t}$ = The market return during time t.

From this, they can test the hull hypothesis that $AR = 0$. They find that this methodology is empirically robust under a variety of conditions, including non-normality in the underlying returns. Kothari and Warner (1997) demonstrate that longer-term event studies are subject to misspecification due to biases in the measurement of abnormal returns and the standard deviation of those returns.

The use of event studies in real estate analysis has not been as well or as long established. Such use has recently been illustrated by Fu and Ching (2001) and Sing, Ho, and Mak (2002). The use of an event study methodology is also detailed in Bhagat and Romano (2001).

Model Development

Following the methodology developed in the repeat sales literature, a general index of house prices can be developed as shown in Equation 2.

$$AAR_{t,t+n} = \frac{\sum_{m} \left(\frac{sp_{i,k}}{sp_{i,j}}\right)^{1/k-j} - 1}{m}. \tag{2}$$

Where: AAR = Average Annual Returns from time t to time $t + n$;
sp = Selling price of house i at the end of years j and k; and
m = Total number of houses in the index.

Note that this index is expressed in years, but is generalizable to any compounding period or to continuous compounding. Note also that, in practice, house sales and resales are rarely exact numbers of years apart and instead are some fractions of months and years. However, in practice, the summation works well as long as consistent timeframes are used and the individual returns are converted into a common base (e.g., daily, monthly, quarterly, yearly). For the empirical analysis portion of this study, yearly AARs are computed using data reported in monthly time frames, to accommodate variations in reporting by the multiple listing service (MLS). Finally, note that periods j and k are contained within the time boundary t to $t + n$.

For purpose of the event study, the time frame, j through k, should span the event in question. The hypothetical impact of the contamination event is shown in Exhibit 1.

In Exhibit 1, a hypothetical contamination event or announcement occurs at the end of year 5. Until that time, house values in the subject market had been trending upward. After the event, house prices reacted negatively to the event over a period of two years, then stabilized, and began to grow again in years 4 and 5, albeit at a slower rate. Note that this particular pattern is offered for illustrative purposes only. The actual pattern of price/value decline, stabilization, and post-event equilibrium can be empirically determined on a case-by-case basis. However, this sort of pattern is generally consistent with the practitioner valuation literature and anecdotal evidence.

A full understanding of the stigma impacts of the contamination requires some understanding of this change in the price-return stream over time. Unfortunately, house prices are only observable at the time of a sale, while house values, which are unobservable, grow during years between the repeat sales. Thus, a sale of a house after the event, during years 6–10 or beyond, would only truly measure the impact of the stigma if the prior sale had occurred immediately *before* the contamination announcement.

To accommodate this, the specific annual growth rate, g, occurring after the event needs to be extracted via a geometric mean. AARs before the event can be estimated using only the subset of repeat sales with a second sale prior to the event. Then, sales occurring after the event are added to the data set in one-year increments. The one-year spot return rate, g, for the first year after the event, assumed in this formulation to be year 6, can then be estimated using Equation 3.[1]

$$g_6 = \frac{(1 + AAR_{1-6})^6}{(1 + AAR_{1-5})^5} - 1. \qquad (3)$$

Once g_6 is estimated, then for each subsequent year, m, the one-year spot growth rate can be estimated via Equation 4.

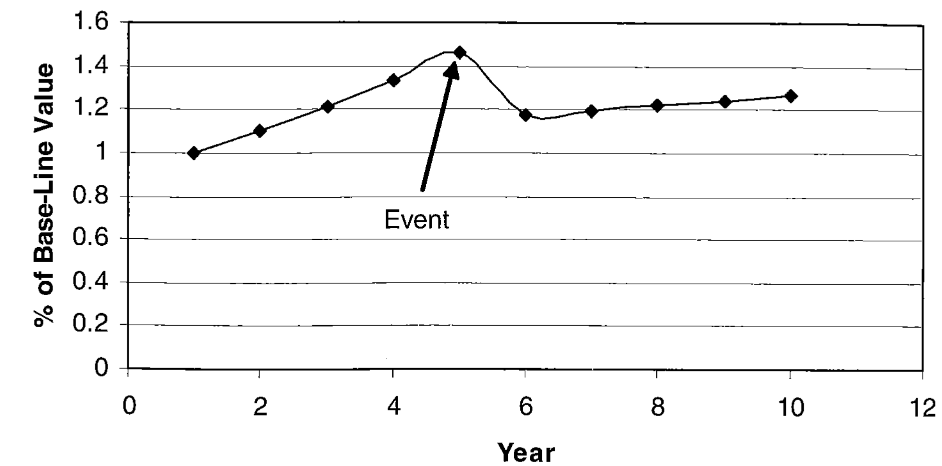
$$g_{m=7\ to\ 10} = \frac{(1 + AAR_{6\ to\ m})^m}{(1 + AAR_{1-5})^5 \prod_{n=6\ to\ 9} (1 + g_n)} - 1. \qquad (4)$$

Note that Equation 4 is simply a generalizable extension of Equation 3, and may be used for any number of periods before and after the event in question.

Empirical Data and Estimation Results

Data for this study were gathered from home sales in southern Santa Clara County, California, commonly known as the San Martin area, before and immediately after an announcement of perchlorate contamination of the area's drinking water supplies. Perchlorate is often called "rocket fuel" and is commonly used as a trigger mechanism in flares and other similar devices.

Exhibit 1. Hypothesized Value Impact of Contamination Event



Neighborhood Description and the Contamination Event

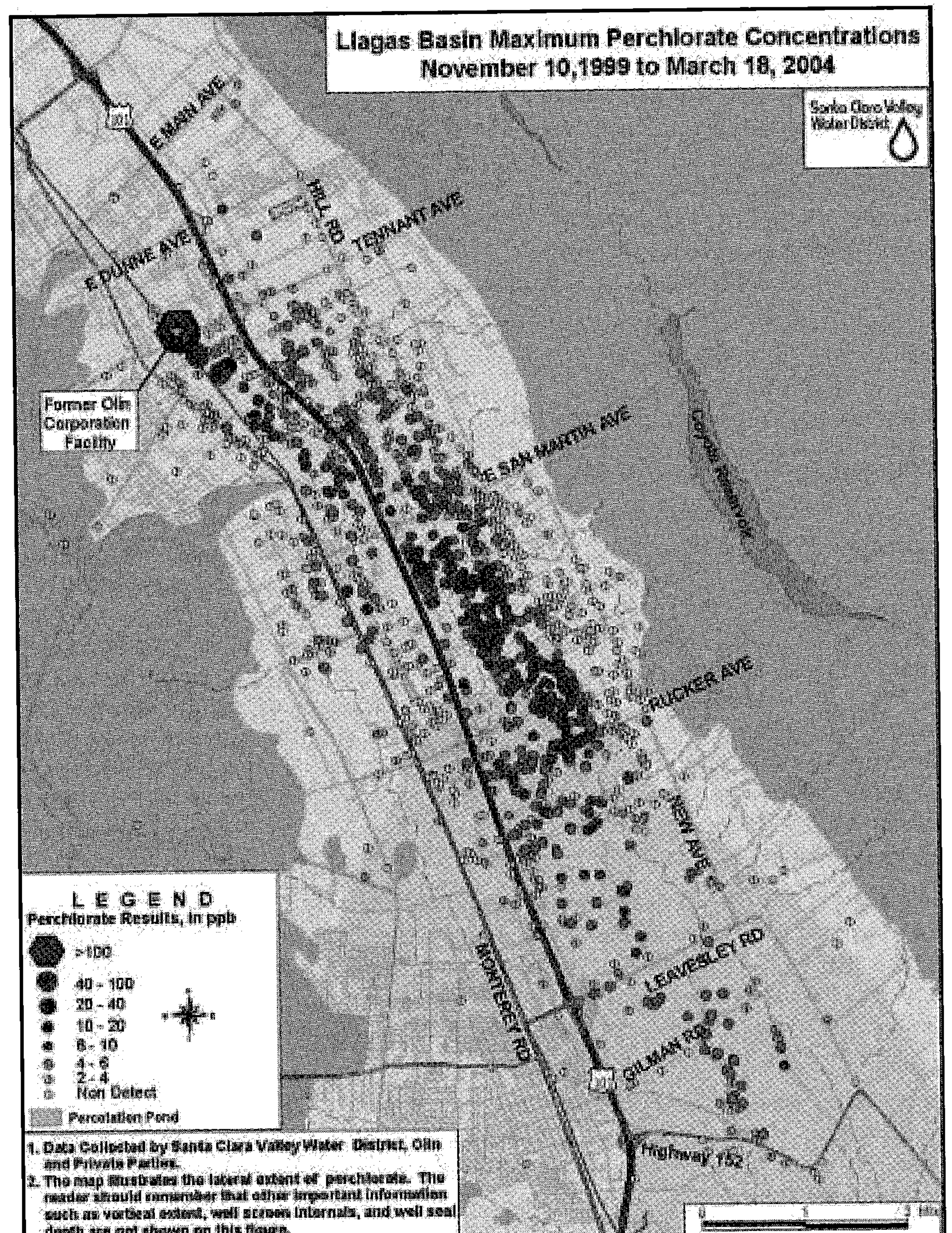
The study area is generally zoned for single family detached homes on five-plus acre homesites. Nearly all potable water is provided from individual home wells or small owner-operated water companies (generally a few households sharing a common well). The market area generally contains upscale homes ranging in price (as if unimpaired) from \$600,000 to \$8.5 million. Many of the homeowners commute into work in San Jose, in the northern end of the county, and the neighborhood is served both by the California 101 freeway and commuter rail. Prior to the event in question, the neighborhood enjoyed robust sales volume and price appreciation, as is typical of the bay area. The relatively constrained housing supply in Santa Clara County coupled with pent-up demand served to insulate housing prices in the region from most of the ill effects of the NASDAQ meltdown a few years ago, which otherwise had its epicenter in Santa Clara County's high-tech corridor.

On January 13, 2003, local newspapers reported that the Santa Clara County water authorities had found measurable levels of perchlorate in some of these wells. California does not have an action standard for perchlorate, but other states do and the levels in many of the wells exceeded standards recommended by many toxicologists and physical scientists. Ingestion of perchlorate has been reportedly linked to thyroid ailments, prenatal concerns, and other human health effects.

Note: The purpose of this paper is not to establish or allege any particular human health effects of perchlorate contamination, but only to test useful methods for appraising home value reactions to an announcement of such a contamination event. The foregoing information, gleaned from local Santa Clara County news reports, is offered only to provide background to the reader as to the information available to market participants following January, 2003.

Following the initial announcement, wells serving all of the homes in the San Martin region were tested with varying results, as shown in Exhibit 2. The point-source of the

Exhibit 2. Liagas Basin Maximum Perchlorate Concentrations November 10, 1999 to March 18, 2004



contamination was determined to be a brownfield site at the north end of the San Martin area, which was a former road flare manufacturing plant. The responsible parties were determined, and these parties agreed to begin providing testing and delivery of bottled water to homes in the affected area.

For a period of several months following the announcements, there were no market transactions of homes in the neighborhood. Anecdotal evidence, including extensive interviews with homeowners, brokers, appraisers, and other market participants indicated that listings were pulled off the market, financing fell through, and home renovation ceased. By late 2003, homes began selling again, and a market equilibrium appeared to re-emerge in 2004.

Often, some type of cross-sectional model would be useful for measuring the disruption in home values. For example, a hedonic model using prices from both the San Martin area and one or more unaffected control areas may give some indications of value impacts, assuming all of the necessary and sufficient conditions for a restoration of market equilibrium existed. However, this would require one or more control areas that were comparable to the San Martin neighborhood but for the contamination. Unfortunately, San Martin is a unique neighborhood in Central California, and cross-sectional comparables were not easily obtainable.

An examination of other unaffected (but non-comparable) neighborhoods in the region indicated that long-term price trends that existed prior to January, 2003 were continuing in 2003 and 2004. Hence, with the assumption that, but for the contamination, the San Martin neighborhood would have been affected by the same market forces as these other neighborhoods, suggests that a longitudinal model may be illustrative of the value disruption, if any, immediately following the contamination announcement. With that, the sales data from late-2003 and 2004 were ripe for examination using the model presented earlier.

Sales Data: Prior to the Event

A 100% sample of sales data for the affected neighborhood was collected from 1990 forward for residences with two arms-length transactions, the first closing before 1999 and the second transaction closing during calendar years 1999–2002.[2] For each sale-resale, the home was inspected to determine if there was any evidence of economically significant improvement in the property. A summary of sales data for these years is shown in Exhibit 3. A total of 83 repeat sales pairs were found. Of those,11 sales were found to be problematic and were excluded from the sample, leaving 72 useful sales.

Robust sales data were not available for the neighborhood prior to 1990. Additionally, homes in the neighborhood tend to be held for about six years (with 1999 being the exception). As a result, repeat sales with a second sale prior to 1999 were not found to be contributory to the study due to diminishing sample sizes in earlier years.

Exhibit summarizes 72 pairs of sales, each of which was about six years apart, on average. During that approximate six-year period, homes appreciated approximately 11.62% per year. It is important to note that the individual Average Annual Return (AAR) for each year is not indicative of the actual housing price returns for San Martin for that specific year, but instead is indicative of the average compound annual return experienced by

Exhibit 3. Pre-Contamination Sale-Resale Summary Statistics

Year	# of Sales	Avg. Tenure	AAR	Std. Dev.
1999	23	4.0 years	11.43%	7.87%
2000	20	6.4 years	12.46%	5.59%
2001	9	6.4 years	12.70%	5.09%
2002	20	5.7 years	9.88%	5.71%
Summary	72		11.62%	

homes with a second closing in that particular year. To disaggregate the average return for year *t*, it would be necessary to compare the compound average returns for homes closing year *t* to the compound average returns enjoyed by homes closing in years prior to year *t*, in a manner following the generalized model show in Equation 4. This is the empirical goal of the following sections.

Sales Data after the Event

Two years of data were gathered for sales after the event—2003 and 2004. These are summarized in Exhibit 4. Note that sales volume actually increased slightly from 2002 to 2003, despite the disequilibrium in the first-half of the year resulting from the contamination announcement, and significantly increased in 2004. This is a manifestation of three different phenomenon. First, with a fixed beginning year for the entire study (1990), it is natural that repeat sales will grow over time simply through tenure choices by homeowners. Second, leading up to the contamination event, there was significant construction in the neighborhood, leading to generic growth in the number of sales. Finally, while prices in Santa Clara County did not appear to be affected by the events of 2000–2001 (e.g., the NASDAQ meltdown, 9/11, etc.), interviews with local market participants indicate that there was certainly a decrease in sales volume, as is evidenced in Exhibit 3. However, it was believed that by the end of 2002, this 'volume shock' was fully absorbed into the market.

At first glance, the AARs for 2003 and 2004 do not appear meaningfully different from the results found in 1999–2003. However, recall that these are the results of a compound function, and include both pre-2003 growth at an average annual rate of 11.62%, as well as post-event growth or decline at some unknown rate.

Exhibit 4. Post-Contamination Sale-Resale Summary Statistics

Year	# of Sales	Avg. Tenure	AAR	Std. Dev.
2003	27	6.5 years	8.41%	4.63%
2004	50	5.8 years	9.77%	5.45%
Total	77			

To solve for these unknown rates of value growth, Equation 3 and 4, respectively, are applied to the data presented in Exhibit 4. The calculation for 2003 is shown in Equation 5, which is adapted from Equation 3:

$$g_{2003} = \frac{(1 + .0841)^6}{(1 + .1162)^5} - 1 = -6.31\%. \quad (5)$$

This equation extracts the one-year growth rate for 2003 (g_{2003}) by extracting the pre-2003 growth from the overall growth in prices for paired resales concluding that year. The calculation for 2004 should include both pre-2003 growth rates as well as 2003's growth rate, and is calculated in Equation 6, which is an extension of Equation 4:

$$g_{2004} = \frac{(1.0977)^6}{(1.1162)^4(1.0841)} - 1 = 3.96\%. \quad (6)$$

Equation 6 shows that the overall growth for paired re-sales transacting in 2004 included four years of growth at 11.62% and one-year of growth at 8.41%. The rebound in prices, while substantial on a one-year basis, still did not bring the overall AAR of 9.77% up to the pre-contamination level of 11.62%.

Summary of the Sales Data

This analysis supports the hypothesis that real estate values in the neighborhood fell during the year following the contamination announcement, but were at least partially restored during 2004, as shown in Exhibit 5. Further, and as an aside to this analysis, sales volume for 2004 was robust, consistent with a hypothesis of a rebounding market and consistent with the qualitative model described in Exhibit 1.

Implications for Real Estate Appraisal

Note that the preceding calculations only estimated actual growth rates of prices and values in the neighborhood in the two years following the contamination event. The missing element is the implication for real estate values as of the end of 2003 or the end of 2004.

To do so on a neighborhood-wide basis, it is necessary to determine what prices *would have been* had the contamination not occurred, and compare those with prices *as they actually occurred* at various points in time. As indicated in a previous section, anecdotal evidence from other neighborhoods in Santa Clara County indicates, within a reasonable

Exhibit 5. One-Year Growth Rates

Year	Growth Rate
Pre-2003	11.62%
2003	−6.31%
2004	3.96%

degree of appraisal certainty, that prices in San Martin would have continued to increase at pre-2003 rates but for the contamination. Thus, the appraisal value of extracting one-year growth rates is to use this as a tool to compare prices neighborhood-wide to what values would have been, or to put it in appraisal terms, to determine a market conditions adjustment under the very specific circumstances of a market disruption resulting from a contamination event.

As shown in Exhibit 6, but for the contamination, a typical house in the neighborhood would have grown in value from, say, $100,000 to $124,590 in two years—the effect of compound growth in value at the rate of 11.62% per year. However, the actual observed prices in the neighborhood fell from January 1, 2003 to December 31, 2003, by 6.31%, then rebounded by 3.96% the following year. Compared to an unimpaired house, this amounts to a 21.82% diminution in value as of December 31, 2004.

Implications for Further Research

While repeat-sales indices are well established in the valuation literature, this is one of the first studies to use such an index to measure the impact of a contamination event. Implicit in this study are several implications worth of further research:

1. There is an assumption in the methodology that the transactions are all by knowledgeable buyers and sellers. In fact, prior research in the field has suggested that markets are slow to adapt to an impact such as contamination, and that prices may not be fully reflective of the knowledge of the event. As such, the diminution measured may actually be a diminution in market prices, not market values, with the actual diminution in values somewhat lower than measured.
2. This particular data set arbitrarily cuts off at the end of 2004, without any exploration of whether or not the market has fully stabilized into a new equilibrium. The long-run nature of that equilibrium should be explored in future research.
3. While the error rates and other statistical properties of repeat sales indices are well known in the literature, this particular application is ripe for further testing.
4. Event studies from the finance literature as well as repeat sale indices are typically developed with larger data sets that are more robust to parametric methods. However, Barber and Lyon (1996) explore event studies using accounting literature and test for significance using a non-parametric Wilcoxian test. They find that the non-parametric methodology is more powerful in such situations.

Exhibit 6. Hypothetical Values and Observed Prices for 2003 and 2004

Year	Unimpaired Values	Observed Prices
January 1, 2003	$100,000	$100,000
December 31, 2003	$111,620	$93,690
December 31, 2004	$124,590	$97,400
$ Diminution		$27,190
% Diminution		21.82%

Endnotes

[1] Implicitly, this assumes that growth rates during the years running up to the event in question were stationary. This was separately tested as a separate analysis outside the scope of this paper, and the null hypothesis of stationary growth rates during the period before the event could not be rejected at a p-value of 98%.

[2] The data set was purged of non-arms length transactions, transactions occurring with a gap of less than one year (suggesting speculative flipping), and transactions which evidenced substantial physical changes in the property.

References

Abdalla, C.W., B. Roach, and D. Epp. Valuing Environmental Quality Changes Using Averting Expenditures: An Application to Groundwater Contamination. *Land Economics*, 1992, 68, 163–9.

Bailey, M.J., R.F. Muth, and H.O. Nourse. A Regression Method for Real Estate Price Index Construction. *Journal of the American Statistical Association*, 1963, 58, 933–42.

Barber, B. and J. Lyon. Detecting Abnormal Operating. Performance: The Empirical Power and Specification of Test. Statistics. *Journal of Financial Economics*, 1996, 41, 359–399.

Baroni, M., F. Barthelemy, and M. Mokrane. A PCA Factor Repeat Sales Index (1973–2001) to Forecast Apartment Prices in Paris (France). ESSEC Centre de Recherche working paper. February, 2005.

Bhagat, S., and R. Romano, Event Studies and the Law—Part I: Technique and Corporate Litigation. Yale Law School John M. Olin Center for Studies in Law, Economics, and Public Policy Working Paper Series. Paper 259. 2001.

Bible, D., C. Hsieh, G. Joiner, and D.W. Voluntine. Environmental Effects on Residential Property Values Resulting from the Contamination Effects of a Creosote Plant Site. *Property Management*, 2002, 20:5, 383–91.

Boyle, M. and K. Kiel. A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities. *Journal of Real Estate Literature,* 2001, 117–44.

Brown, S. and J. Warner. Measuring Security Price Performance. *Journal of Financial Economics*, 8, 1980, 205–58.

——. Using Daily Stock Returns: The Case of Event Studies. *Journal of Financial Economics*, 14, 1985, 145–66.

Case, K.E. and R.J. Shiller. Forecasting Prices and Excess Returns in the Housing Market. *Journal of the American Real Estate and Urban Economics Association*, 1990, 18:3, 253–73.

Clapp, J.M. and C. Giaccotto. Evaluating House Price Forecasts. *Journal of Real Estate Research*, 2002, 24, 1–26.

Clapham, E., P. Englund, J.M. Quigley, and C.L. Redfearn. Revising the Past: Revision in Repeat Sales and Hedonic Indexes of House Prices. Paper presented to the Homer Hoyt Institute, May, 2003. Revised August, 2004. Working paper available through the Department of Economics, University of California at Berkeley.

Edelstein, M. Contaminated Communities: The Social and Psychological Impacts of Residential Toxic Exposure. Boulder, CO: Westview Press, 1988.

Fu, Y. and S. Ching. Examining Competition in Land Markets: Application of Event Study to Land Auctions in Hong Kong. Paper presented at the American Real Estate and Urban Economics Association annual meetings, January, 2001.

Gamble, H.B. and R.H. Downing. Effects of Nuclear Power Plants on Residential Property Values. *Journal of Regional Science*, 1982, 457–78.

Goetzmann, W. and M. Spiegel. Non-temporal Components of Real Estate Appreciation. *Review of Economics and Statistics*, 1995, 77, 199–206.

Kiel, K.A. Measuring the Impact of the Discovery and Cleaning of Identified Hazardous Waste Sites on Housing Values. *Land Economics*, 1995, 71:4, 428–35.

Kinnard, W. Measuring the Effects of Contamination on Property Values. *Environmental Watch*, 1992, Winter, 1–4.

Khotari, S.P. and J.B. Warner. Measuring Long-Horizon Security Price Performance. *Journal of Financial Economics*, 43, 1997, 301–39.

——. Econometrics of Event Studies. Chapter 1. *Handbook of Corporate Finance: Empirical Corporate Finance*. B.E. Eckbo (Ed.), Elsevier/North Holland, 2005.

McMillen, D.P. The Center Restored: Chicago's Residential Price Gradient Reemerges. *Economic Perspectives*, 2002, 2–11.

Mundy, B. Stigma and Value. *The Appraisal Journal*, 1992a, 7–13.

——. The Impact of Hazardous and Toxic Materials on Property Values. *The Appraisal Journal*, 1992b, 155–62.

——. The Impact of Hazardous and Toxic Materials on Property Values–Revisited. *The Appraisal Journal*, 1992c 463–71.

Page, G.W. and H. Rabinowitz. Groundwater Contamination: Its Effects on Property Values and Cities. *APA Journal*, 1993, Autumn, 473–81.

Patchin, P.J. Contaminated Properties—Stigma Revisited. *The Appraisal Journal*, 1991, 167–72.

Pennington-Cross, A. Aggregation Bias and the Repeat Sales Price Index. Office of Federal Housing Enterprise Oversight Working Paper 03-3. December, 2003.

Pollakowski, H.O. Data Sources for Measuring House Price Changes. *Journal of Housing Research*, 1995, 6:3, 377–87.

Pollakowski, H.O. and T.S. Ray. Housing Price Diffusion Patters at Different Aggregation Levels: An Examination of Housing Market Efficiency. *Journal of Housing Research*, 1997, 8:1, 107–24.

Reinsdorf, M.B., W.E. Diewert, and C. Ehemann. Additive Decompositions for Fisher, Tornqvist, and Geometric Mean Indices. *Journal of Economic and Social Measurement*, 2002, 28, 51–61.

Simons, R.A. Estimating Proximate Property Damage from PCB Contamination in a Rural Market: A Multiple Technique Approach. *The Appraisal Journal*, 2002, 388–400.

Sing, T.F., K.H.D. Ho, and M.F.E. Mak. Real Estate Market Reaction to Public Listings and Acquisition News of Malaysia REITs. Paper presented at the Asian Real Estate Society Conference, Seoul, Korea, July, 2002.

Stephens, W., Y. Li, V. Lekkas, J. Abraham, C. Calhoun, and T. Kimner. Conventional Mortgage Home Price Index. *Journal of Housing Research*, 1995, 6:3, 389–418.

Wang, F.T. and P.M. Zorn. Estimating House Price Growth with Repeat Sales Data: What's the Aim of the Game? *Journal of Housing Economics*, 1997, 6, 93–118.

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