

Analysis & Perspective

'Peer-reviewed' isn't necessarily a stamp of reliability, according to author Albert R. Wilson. His research into peer-reviewed real estate literature on the impact toxic and hazardous waste on property valuation has lead him to conclude that the existing process of vetting professional articles gives the imprimatur of reliability to flawed analysis.

Wilson offers a list of 'minimum requirements' for a peer review process that will let "other researchers, attorneys, experts and the courts" judge the reliability of the paper.

The Questionable Reliability of 'Peer Reviewed' Real Estate Literature

BY ALBERT R. WILSON, CRE

Abstract

Over the past several decades the real estate literature has prominently featured analyses of alleged detrimental conditions such as air pollution, gas station leaks, hazardous and non-hazardous waste landfills, and power lines on property values. A segment of this literature has been based on "hedonic modeling," "predictive regression" and other econometric techniques that are not mathematically or scientifically supportable. Further, the peer review practices of the literature in the field has been editorial in nature without full disclosure of that fact leading the reader to place unjustified reliance on the information provided. This article reports some of the results of a six year study of such literature and details a number reasons why such literature cannot be relied upon by other researchers, attorneys, experts or the courts. A series of suggestions to improve reliability are offered based on this research.

Introduction

Over the past six years the author has been engaged in funded¹ and unfunded research into the reliability of a segment of the "peer reviewed" real estate literature.

¹ Research was generally funded as a part of litigation support efforts over a period of years for multiple clients and multiple matters. Extensive funded research was associated with the validation of the information contained in the three articles to be used as illustrations of the problems of peer review. None of the clients involved in the funded portions of this research have had any input into this article or into the unfunded research supporting it.

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That segment may be identified as those papers using techniques such as "hedonic modeling" and "predictive regression" as a primary analytical tool for detrimental condition analysis. This paper presents some of the results of that research. The outstanding conclusion is that the existing "peer review" process results in literature of questionable reliability.

Compounding this problem is the fact that there is currently no positive mechanism to inform readers of erroneous literature once it has been identified.² This leaves the consumer in the dark as to when reported research may be trusted, and when it may not. This article looks at issues common to more than 90 papers³ examined by the author during the course of the research and focuses on three of them as being illustrative of the problem.

As pointed out by Effie Chan in an article in the *New York Law Review*⁴, there are two types of peer review and one must be very careful to understand the limitations associated with each. The two types of peer review may be operationally defined as:

Editorial Peer Review: Indicating that an article had been deemed acceptable for publication in a journal based on a review using criteria of perceived value to the readership and adherence to measures of acceptable content. The review is generally limited to the information provided in the text of the article and the background knowledge of the reviewer(s).⁵

² So-called "letters to the editor" have no standing in court and generally are ignored by most consumers of the "peer reviewed" literature and therefore are not considered to be a reliable or appropriate correction mechanism.

³ The 90 plus papers were selected primarily on the basis of the frequency with which later authors cited to those papers in a favorable manner. Several papers were selected based on the fact that the underlying database supporting the research were made available to the author for re-analysis.

⁴ Chan, Effie J., "The 'Brave New World of Daubert: True Peer Review, Editorial Peer Review, and Scientific Validity,'" *New York University Law Review*, April, 1995, 70 N.Y.U.L. Rev. 100.

⁵ The reader is not generally explicitly told that the peer review is actually editorial peer review. However, some limiting

True, or Scientific Peer Review: In this type of review not only the information contained in the article itself is reviewed, but the raw data, analytical techniques, and conclusions are subjected to analysis by individuals competent in the field(s) utilizing the scientific method (principle of falsification). This type of review theoretically has no final conclusion, only the conclusion that—based on all of the available information and knowledge of the time—the hypotheses may be tentatively accepted.

The real estate literature may be accurately described as being "editorially peer reviewed" with all of the limitations on reliability implied by the above definition. There is no detectable attempt on the part of the real estate literature to provide "true or scientific peer review", nor has that literature ever claimed that such an extensive review takes place. The problems discussed here result primarily from the misperceptions of the consuming public as to the meaning of the unqualified phrase "peer review," the failure of the publications to insure that the reviews that do take place are properly performed within the context of their review process, and a failure to publish research that refutes the results of earlier articles.

The papers studied as a part of this project were taken from the following publications.

American Economic Review
American Journal of Agricultural Economics
Journal of Regional Science
Journal of Applied Economics
Land Economics
Journal of Urban Economics
Risk Analysis
Journal of the American Real Estate and Urban Economics Association
The Real Estate Appraiser
The Appraisal Journal
Journal of Real Estate Research

The three papers that will be used to illustrate the problems and issues are by a common principal author published in *The Appraisal Journal*; specifically "The Price and Liquidity Effects of UST Leaks from Gas Stations on Adjacent Contaminated Property" (hereafter, *Price and Liquidity*)⁶ and "The Effects of an Oil Pipeline Rupture on Single-Family House Prices" (hereafter,

statement may be provided by the publication. The *Appraisal Journal* for example carries the following as a "Mission Statement": "The *Appraisal Journal* is published to provide a peer-reviewed forum for information and ideas on the practice and theory of valuation and analysis of real estate and related interests. *Journal* articles do not necessarily represent Appraisal Institute policies, positions, or procedures. Rather, *The Appraisal Journal* presents ideas, concepts, and possible appraisal and analytical techniques to be considered; some articles are for the development and expansion of appraisal theory while others are useful in the evolution of practice." In the Disclaimer section: "The opinions and statements set forth herein do not necessarily reflect the viewpoint of the Appraisal Institute. While care has been taken to provide accurate and current information, neither the Appraisal Institute nor its editors and staff assume responsibility for the accuracy of the information contained herein." *The Appraisal Journal*, July 2003. In the *Journal of Real Estate Research* there is virtually no statement concerning these issues.

⁶ Robert A. Simons, PhD; William M. Bowen, PhD, and Arthur J. Sementelli, PhD, "The Price and Liquidity Effects of UST Leaks from Gas Stations on Adjacent Contaminated Property," *The Appraisal Journal*, April, 1999.

Pipeline Rupture)⁷ and in the *Journal of Real Estate Research*; "The Effects of Underground Storage Tanks on Residential Property Values in Cuyahoga County, Ohio" (hereafter, *UST Effects*)⁸. I had the opportunity as a result of litigation to thoroughly investigate all of the available information supporting these three papers. Some of that information will be presented to illustrate the issues.

Database Preparation: External and Internal Validation, Editing and Selection

The validity of the data supporting any analysis is of critical importance. It is insufficient to simply collect data from some source and employ that data without carefully validating it by appropriate and reliable methods.

The first validation step is external to the database. Appraisers would recognize this as confirmation of sales data wherein the information from the public record is checked against other data sources—ideally a sale participant—to determine if the information is correct and accurate and if there were any unusual conditions or circumstances influencing the sale price. Absent, or in addition to, a primary source such as a sale participant other sources of confirmation are sought such as title and mortgage documents, MLS data and the like. External validation may be defined as:

External Validation: Validation of the information in the database against primary and/or secondary sources to determine the accuracy and applicability of the data for the purpose of the analysis to be conducted. In the case of very large databases this may involve statistical sampling techniques when 100% validation is impractical. If statistical sampling techniques are employed they should be carefully documented.

The second step is primarily internal to the database. The objective of internal validation is to insure that the data are internally consistent and appropriate for use by a given analytical approach or technique. For example if the data has year constructed and age it is appropriate to insure that these two values agree. If only year constructed is provided then it is important to make sure that the value is not blank (which may be interpreted as the property having been constructed in 1900 or 2000, for example), or is within a reasonable range for the situation.

This part of the procedure may include the elimination of inappropriate data such as sales within an unusually short period of time (possible "flipping"). If the year built is critical to the analysis and it is unavailable for a particular datum, then that data element must be eliminated from the database. Internal validation is critical and must be carefully documented to insure that no misunderstandings result that might compromise the objectivity of the research.

In one situation reviewed an examination of the database indicated that the researcher had eliminated all but one of the homes with a blank year built from a da-

⁷ Robert A. Simons, PhD., Kimberly Winson-Geldeman, and Brian A. Mikelbank, PhD, "The Effects of an Oil Pipeline Rupture on Single-Family House Prices," *The Appraisal Journal*, October, 2001.

⁸ Robert A. Simons, William Bowen, Arthur Sementelli, "The Effect of Underground Storage Tanks on Residential Property Values in Cuyahoga County, Ohio," *Journal of Real Estate Research*, Volume 14, Number 1/2, 1997.

tabase containing approximately 1,800 homes. This home was in the allegedly impacted area and the researcher concluded that a diminution in value was statistically significant. A re-analysis of this database using exactly the same analytical procedures and software but after deletion of that one single home reduced any alleged diminution to statistical insignificance. This experience illustrates both the importance of proper internal validation and the extreme fragility of hedonic modeling results.⁹

Internal validation may be defined as:

Internal Validation: Validation of the information to insure that it is internally consistent and that information of questionable integrity is not included in the proposed analytical database. Sampling techniques are not appropriate in this type of validation, 100% of the data must be analyzed. Careful documentation is required in order to assure that another researcher may understand the work performed and be able to replicate it.

The next step is to edit and select that portion of the validated database to be used in the actual analysis. For some reason many academic researchers appear to avoid this step, apparently in a misunderstanding of statistical theory believing that gross volume of data is preferable to an appropriately selected set of homogeneous data. A small amount of high quality homogeneous data is preferred to a large amount of heterogeneous data for statistical analysis purposes. In fact, too many data points can lead to misleading indications of significance, for example.

Appraisers will immediately recognize the problem in the context of the process of selection of comparable sales—comparable sales must be as similar to the subject as possible in order to minimize the need for adjustments—in other words the comparable sales are homogeneous with the subject. Statistical analysis also requires a homogeneous sample set for the same reasons and sheer numbers of sales do not offset that requirement. To the extent that a sample set is not homogeneous the validity of any statistical results will be compromised.

In many of the articles examined, few clues were found concerning how the external or internal validation or the editing and selection processes were performed, if they were performed at all. In the illustrative papers discussed here, it was found that the authors did very little validation or editing/selection of any type, simply accepting the information from the public record as the gospel truth when in fact a properly performed validation exercise revealed numerous fatal flaws in this assumption.

In *UST Effects*, the principal author, in sworn testimony, stated that they (the team of authors and researchers) had attempted to validate (in at least some minor and cursory sense) 25 of the 16,990 property sales used in that analysis, being essentially every sale of residential property recorded in the county assessor's database for that year.¹⁰ Further, they had not at-

⁹ Report and supporting data of Dr. Barton Smith prepared in the matter of *Mike Adalla et al v. Neighborhood Development Corporation et al*, 269th Judicial District, 93-0464, data analyzed by the author and Dr. Warren Rogers.

¹⁰ The *UST Effects* paper contains the following: "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

tempted to determine if the presence of a registered leaking underground storage tank had in any way influenced or been any part of the considerations of the participants in the sales transactions, except in less than ten instances. The assumption was that a registered leaking underground storage tank negatively influences value based on the knowledge of its presence in the marketplace. This assumption of knowledge was ill-founded and contrary to other contemporaneous research conducted under the auspices of the principal author.¹¹

The principal author stated that the research databases supporting this article and that supporting *Price and Liquidity* had been destroyed upon learning that the papers had been accepted in a "peer reviewed" publication.¹²

We could not verify all of the data in Tables 1 or 2 below taken from *Price and Liquidity* because of the passage of time (five to 22 years), the disinclination of some of the sale participants to discuss in detail an event years in the past, and the principal author's destruction of the supporting data. All of the following information was gathered by a professional team consisting of this author, a local historian, and a local real estate appraiser in 2000 and 2002.¹³

The Predicted Price in Table 1 is calculated according to:

Given the available data, the best analytical techniques for existing residential sales is individual prediction using hedonic multiple regression analysis, with data transformed using the Box-Cox technique... This technique enables comparison of predicted sales price with the actual sales price. The difference can be attributed to contamination, holding all other information constant. The following table contains the results. The most important information includes the percentage reduction in value between the predicted and observed sales prices.

Eleven existing residential properties were sold after contamination was known to be initiated. Comparing the actual sales price with its predicted (market) price among this group, nine have a statistically significant reduction in price, one has a reduction that is not significant, and one has a significant increase in sales

properties were residential in use." page 35. In later sworn testimony the principal author stated that the only attempt at verification through contact with a transaction participant involved less than 10 properties.

¹¹ In research conducted after the original research for *UST Effects* but prior to its publication the principal author's graduate student conducted a survey that indicated 74% of residents proximate to a gas station with leaking underground tanks, including those undergoing remediation, were unaware of the activities. Robert A. Simons, PhD and Patrick T. Barney, Graduate Student; "Investigation of Underground Storage Tank Leakage in Cuyahoga County: Effects on Local Property, Residents, and Liable Parties," M. S. Urban Studies Project, Cleveland State University, 1994.

¹² Simons Depo. in *Lynn v. AMOCO*, May 22, 2000, page 187 and numerous other instances.

"Q. With respect to Exhibit No. 4 [Price and Liquidity], apart from the report itself, do you have any other backup data or backup information which you had gathered to write the paper itself?

A. No. When the paper was accepted for publication, we cleaned the files out."

¹³ Mr. Robert Neil and Mr. Bruce Buckholz, SRA provided invaluable assistance and a large volume of local research and information.

price. Aggregating these sales together reveals a 14%-15% reduction in sales price that can be attributed to the LUST contamination, without accounting for delay or other impacts on value.

Price and Liquidity, ibid., page 191.

Note that these will be predicted prices for a new sale and fall under the broader statistical confidence limits

discussed below under Analytical Tools. Suffice it to say for the moment that the predicted prices used in this table are virtually meaningless given the extremely broad confidence limits that apply.

TABLE 1 Existing Residential Properties Sold After 1994 with Disclosure in Effect

Year Sold	Parcel Map and Page	Degree of Contamination	Actual Price	Predicted Price	Price Difference	Price Change Predicted	Note
1994	821-18	3	\$ 72,000	\$ 98,280	-\$ 26,280	-26.7%*	A
1994	312-05	3	\$102,000	\$131,453	-\$ 29,453	-22.4%*	B
1995	363-15	2	\$103,000	\$ 85,440	\$ 17,560	20.6%*	C
1995	134-23	2	\$ 20,000	\$ 32,169	-\$ 12,169	-37.8%*	D
1995	018-04	2	\$ 61,000	\$ 64,467	-\$ 3,467	-5.4%*	E
1995	018-04	2	\$ 60,000	\$ 60,699	-\$ 699	-1.2%	F
1995	022-14	2	\$ 53,000	\$ 60,118	-\$7,118	-11.8%*	G
1996	684-01	2	\$ 63,500	\$ 91,780	-\$ 28,280	-30.8%*	H
1996	131-19	1	\$ 15,000	\$ 21,077	-\$ 6,077	-28.8%*	I
1996	018-04	1	\$ 48,000	\$ 51,058	-\$ 3,058	-6.0%*	J
1996	314-21	3	\$129,000	\$145,129	-\$ 16,129	-11.1%*	K
TOTALS			\$726,500	\$841,670	-\$115,170		

* Significant at 0.05

The data on the individual sales in Table 1 are as follows.

A: 821-18-007

This was a sale of a 1930 vintage house. The house was then extensively remodeled (new furnace, electrical service, air conditioning, connection to storm and sanitary sewers, room additions, new roof, etc.) to make it conform to the new housing in the immediately adjacent Aberdeen West subdivision. The home was sold again in 1997 for \$174,900. Current (2002) assessed value \$210,800. Note: There was a second sale of an undeveloped lot to a developer for the same price with the same first five digits of the parcel ID number in the Aberdeen West subdivision immediately adjacent to this property. Because of the destruction of the original information, the lot sale can be confused with the house sale.

B: 312-05-777

This sale could not be confirmed based on the information provided in the article, by the principal author in his deposition, or the public records.

C: 363-15-027

Sale abuts a gas station and is across the street from a fire station. This property apparently sold for \$17,000 more than the "predicted" price.

D: 134-23-006

This property, built in 1900, was sold in 1995 for a reported \$20,000. The property abuts what appears to have been a former service station on Warner Road. The present appearance of the property is excellent on the outside, but the condition at the time of sale is currently unknown.

E: 018-04-156

This property, built in 1923, was sold in 1990 for \$39,000 and again in 1995 for \$61,000 or \$47.47/sqf. Borrowing at the time of the 1995 purchase was \$51,800, or an 85% Loan-to-Value ratio (LTV). The property lies immediately behind and adjoining a former service station. The average sale price for properties in this area not within 300 feet of a UST was \$43.19/sqf in 1995. This property apparently sold at a 10% premium over the average neighborhood property not proximate to a UST, and at an LTV which would indicate that the mortgage lender was not concerned with the alleged presence of a leaking underground storage tank (LUST).

F: 018-04-158

This property, adjacent to -156 above and also built in 1923, was sold in 1995 for \$60,000. This would be \$47.06/sqf versus an average sale price for this area for properties not within 300 feet of a UST of \$43.19/sqf. This property apparently sold at a 9% premium over the average neighborhood property in the area not proximate to a LUST. We note that this property subsequently resold in 1997 for \$60.79/sqf (\$77,500) with a mortgage of \$75,000 (LTV = 96.7%).

G: 022-14-008

This property sold in 1990 for \$40,000 and again in 1995 for \$53,000 with a conventional fixed rate mortgage of \$51,400 (LTV = 97%). The property lies immediately across a busy multi-lane street (W 130th St) from several service stations. The LTV would indicate that the lender was not concerned with proximity to a LUST.

H: 684-01-77?

This sale could not be confirmed based on the information provided in the article, by the principal author in his deposition, or the public records.

I: 131-19-077

This property, built in 1900, transferred twice in 1996, first for an unknown price and then again two months later for a reported (but unconfirmed) \$15,000. The first transfer in 1996 appears to have been an inheritance and the second transfer appears to not have been arms-length. The subject property is approximately 40 feet from a service station. Terms and conditions of sale, and of the property at the time of sale could not be confirmed.

J: 018-04-154

This property adjacent to -156 and -158 above and built in 1922, was sold for \$48,000 in 1996 with an FHA mortgage of \$48,466 (LTV = 100.1%). An analysis of the sale of other properties in this area indicate an average sale price of \$42.31/sqf for those not within three hundred feet of a UST versus this sale at \$52.34/sqf, an indicated premium of 24%. This property is immediately adjoining and behind a former UST location. The seller had owned the property for 51 years at the time of sale.

K: 314-21-77?

This sale could not be confirmed based on the information provided in the article, by the principal author in his deposition, or the public records.

Ignoring for the moment the mathematical meaninglessness of the predicted prices, an examination of the hedonic model used to calculate the "Predicted Price" indicates that the data upon which it was based was from two to four years out of date. The basic hedonic model was originally prepared for study of the Cuyahoga County market for 1992. While the principal author said in his deposition that he updated the independent variable coefficients to 1994, 1995 and 1996, he failed to update the lambda values for his Box-Cox model.

Consider the possibility that just one of the lambda values, the one for sales price, changed from its 1992 value of 0.550 to a new value of 0.560, a difference of 1.82%. Then the value of the predicted sales price would change from \$89,129 to \$72,517, a diminution in value of 18.64%. This one single change in one single parameter would completely account for all of the diminution in value alleged, and more. Real estate regression coefficients have been shown to be highly variable over time,¹⁴ and the Cleveland residential real estate market had been undergoing a significant increase in values during the time periods through 1997.¹⁵ The use of the

¹⁴ Smith, Charles A., Michael E. Hanna, Stephen C. Caples, "Residential Appraising and the Stability of Regression Results Over Time," *The Appraisal Journal*, October, 1999.

¹⁵ Cho, Janet H., "Home values in Cleveland rising faster than in suburbs," *Cleveland Plain Dealer*, May 26, 2000, Source of data: Cuyahoga County Auditor.

same lambda values is extremely poor analytical technique and without foundation.

The predicted diminution in value stated in the article as indicated by the variable CLOSRGLK is \$15,152 with a t-stat of 1.95 and standard error of \$7,766. With respect to CLOSRGLK the principal author stated:

"The results show that for this variable, which combines the potential negative effects of both proximity to hazardous material and a nuisance disutility, there is a negative sign which is statistically significant (in both the Box-Cox and linear models) at $\alpha = 0.05$. 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."¹⁶

First, as a matter of record, the statement is incorrect. The t-stat is 1.95 and the required t-stat for statistical significance at $\alpha = 0.05$ is 1.96. Close but no cigar. The 95% confidence interval surrounding the point estimate of the coefficient contains zero (-\$78 to \$30,382) and we cannot therefore conclude that the coefficient is statistically different from zero. This assumes that the t-stat is a valid measure in the presence of collinearity, which it is not.¹⁷

Note also that we do not know what part of this coefficient represents the influence of the registered leaking underground storage tank, what part represents "nuisance disutility," or what part represents other—unknown—omitted variables, and there is no means to separate these influences. A conclusion that a diminution in value is related to only the presence of a registered leaking underground storage tank is unsupported by the facts of the analysis.

Second, consider that the effect being measured, the alleged impact on value, is \$15,152 but the standard deviation of the prices in the database is \$64,481 or nearly four times the alleged impact. If one looks at R^2 as a measure of explanatory power, then the compliment of R^2 is the unexplained variance between the response variable as predicted by the regression relationship and the actual value in the database. The R^2 for this analysis was 0.78 indicating that 22% of the variation was unexplained—or in this case \$19,038. The effect being measured does not rise above the level of the noise (variability) in the data and is not creditable.

In this same article the principal author attempted to analyze commercial property sales with the following results, indicating that the most basic external and internal validation procedures were not applied.

Note that no attempt was made to adjust sales prices for the influence of time in its many manifestations. These would include physical depreciation, economic obsolescence, changed market conditions between sale dates, and the like. In addition there was no attempt to determine what was actually bought and/or sold such as the car wash equipment or MRI support facilities.

¹⁶ UST Effects, *ibid*, page 38.

¹⁷ For a discussion of this point see for example Neter, *ibid.*, page 294 *et seq.*

TABLE 2 (Originally Table 4 in the article) Commercial Building Sale/Resale Analysis

Land Usage, and Containm. Date	Resale Date	Resale Value	Sale Date	Sale Value	Original Price Change	Orig. Chng	Adj Chng (2% Infl)	Adj Chng at Market Rate	Ref. Notes (See below)
Bowling Alley 5/90	4/96	\$270,000	11/77	\$477,000	-\$207,000	-43%	-61%	-82%	A
Office Building 4/91	12/91	\$530,000	2/86	\$510,000	\$20,000	4%	-6%	-36%	B
Car Wash 4/96	5/96	\$200,000	4/78	\$225,000	-\$25,000	-11%	-38%	-69%	C
Bank 7/90	1/95	\$1,110,150	10/85	\$1,800,000	-\$689,850	-38%	-49%	-66%	D
Comm. 10/90	11/93	\$96,550	1/90	\$190,000	-\$93,450	-49%	-52%	-58%	E
Retail 3/90	3/96	\$91,000	5/84	\$128,600	-\$37,600	-29%	-44%	-64%	F

The information concerning the properties in the above table was as follows.

Property A: Time between sales—19 years

This is a bowling alley built in 1963. It was sold in 1977 from a Lincolnway Lanes to an individual for approximately \$477,000 (unconfirmed). It was sold from that individual to a Lincolnway Lanes in 1996 for \$270,000 (unconfirmed). In a third sale not considered by the principal author because it occurred after the date of his data collection efforts, Lincolnway Lanes then sold the property 18 months later (September 1997) to AMF Bowling Centers for \$1,385,100 (unconfirmed). Interviews of long-time bowlers at the property indicated that the property had become quite run-down prior to the 1996 sale, with immediate renovation and improvement thereafter.

Property B: Time between sales—Five years

This property is a medical building/clinic/MRI facility with all of the special appurtenances and design features normally associated with such use. In the past 14 years it had transferred three times with the last two between entities with either the same or similar names which imply that the transfers may not have been at arms length. The table notes a sale on 2/86 for \$510,000 with a sale on 12/91 for \$530,000 implying a small increase in sale price over the period. We have not been able to develop specific information on the condition of the property or the circumstances of the transfers and simply note that this time period was during the height of the real estate recession in the Cuyahoga County area.

Property C: Time between sales—18 years

This was a sale of a car wash built in 1966. The article lists the sales of 4/78 at \$225,000 and 5/96 at \$200,000 but the principal author stated that he had no knowledge of the condition of the property or of the possibly included/excluded car wash equipment on the date of either sale and therefore no knowledge of any curable or incurable economic obsolescence or depreciation. Further, both sales involved the same individual as buyer and seller. At the time of our 2000 inspection the property and equipment were in a deteriorated condition with obvious salt-water damage to the concrete of the floors and walls of the building.

Property D: Time between sales—10 years

This is not a bank but a multi-story office building constructed in 1975 and is not a single parcel but two parcels facing different streets under common ownership, with one occupied by the office building and the other a parking lot for the building. The property was purchased by a group listed as Lincoln Towers Limited in 1985 with partial funding by Northwestern National Life Insurance Company. This sale is listed at \$1,800,000 in 1985 (confirmed by title documents). The re-sale in January, 1995 at \$1,110,150 (confirmed by title documents) is listed as evidence of a decline in value associated with a gas station leak on an adjoining parcel. However, the second sale was a purchase from foreclosure at a Sheriff's sale by Northwestern National Life for the outstanding mortgage balance.

Property E: Time between sales—Three years

This property is an old, (1920) multi-tenant storefront and apartment building facing Madison St. and West Avenue in a very old section of Cleveland. At least one of the storefronts was empty in 2000 and the property is across the street from a large metal stamping plant, down the street from a plating works, next to one former gas station and across the street from one or possibly two others and in 2000 was generally run down in physical appearance. An interview with the seller revealed that the information in the public records was in error and that the seller sold the property for more than he paid for it although the seller would not confirm the exact sale price. Seller stated that the amount shown in the public records was the amount of the cash down payment only. Seller further stated that he "... was aware that the presence of a leaking gas tank could diminish value but that was not the case with this property." Further he stated that he "had never sold a property for a loss in his life, and this (sale) was no exception."

Property F: Time between sales—12 years

This property was a former auto parts store. The sale listed in March, 1996 for \$91,000 (unconfirmed) was for use as a day care center. It is unknown at the present time whether the sale included or did not include consideration of the cost of conversion from an auto parts store to a day care center. It is noted, however, that a mortgage loan in the amount of \$100,000 with the prop-

erty as collateral was recorded on the same date as the sale.

Other results in this paper contain equivalent analytical flaws.

In *Pipeline Rupture* the principal author failed to validate sales information resulting in treating, for example, an apparently low sale price as resulting from the detrimental condition. Instead it resulted from a pack of unhousebroken dogs defecating in the house to the extent that all of the floor covering and decking had to be removed and replaced to render the home habitable, the cost adjustment that determined the sale price. In this same article a number of internal validation errors in the database were identified and when properly addressed resulted in the principal author stating under oath within weeks of the publication of the article that there was no longer any statistical basis for an indication of a diminution in value. In this case a major internal validation problem was a failure to properly utilize the tax assessor's determination of whether or not a sale was arms-length.

Absent reliable validated data appropriate to the analysis to be performed, the analysis is reduced to a GIGO—Garbage In/Garbage Out—situation.

It is vital that any research paper contain some indication that steps were taken to insure that the data used in the analysis is reasonably reliable.

If such information is not provided and/or does not meet a reasonable standard then the analysis and all results must be considered unreliable.

Absent reliable validated data appropriate to the analysis to be performed, the analysis is reduced to a GIGO—Garbage In/Garbage Out—situation. It is vital that any research paper contain some indication that steps were taken to insure that the data used in the analysis is reasonably reliable. If such information is not provided and/or does not meet a reasonable standard then the analysis and all results must be considered unreliable.

There is virtually no evidence in the illustrative papers or in most of the other papers examined as a part of this research of any substantive data validation or editorial/selection process. It would appear that this vital preparatory step is generally not thought to be of sufficient importance to report the results, assuming it was performed.

Analytical Tools

The papers examined as a part of the research used several analytical tools in common, specifically regression analysis, "hedonic modeling," something called "predictive regression," and general descriptive statistics.

Regression Analysis

Regression mathematics are a well-recognized and very powerful statistical tool with very well-known (at least among mathematicians) assumptions and conditions of use. In regression analysis one forms a hypothetical explanatory relationship for some phenomena or outcome and then examines the data in an effort to understand if that relationship is indeed explanatory. Note the very key and important phrase "... a hypothetical explanatory relationship." The relationship is both hypothetical and explanatory in nature—not absolute and causal.

A regression relationship is composed of six essential parts: (1) The phenomena or response to be predicted, and on the right-hand side of the relationship; (2) The predictor variables¹⁸ believed to have an explanatory relationship to the response; (3) The coefficients of the predictor variables that assign a weight to the influence of a particular predictor variable plus some (generally unknown) weight contributed by any related omitted variables on the response; (4) An error term that addresses the random variability in the data, and; (5) The mathematical form of the hypothetical relationship between the predictor and response variables. The sixth part is frequently ignored—the predictor variables that might have been but were not included in the relationship—the omitted variables.

Because it is a hypothetical relationship, there is no mathematically supportable means of determining causation using a regression relationship.¹⁹ Causation is an issue that must be addressed by a separate and distinct test of the null hypothesis of no influence.

Tests of the Null Hypothesis

A test of the null hypothesis of no influence is vital to the process. If such a test returns an indication that the null cannot be rejected then there is little point in proceeding with the analysis—the data does not indicate an influence and there is nothing to measure.

With the exception of a recently published paper by Wolverton and Bottemiller²⁰ that indicated the null hypothesis could not be rejected in a specific case involv-

¹⁸ The terminology of "predictor variable" is used in this article in place of the older and frequently misleading language of "independent variables" in keeping with current mathematical literature. Modern regression mathematics recognizes that the right-hand side variables in regressions are only very rarely mathematically independent and may or may not have any causal relationship to the response variable, hence the use of the term predictor to minimize any possible confusion and mis-interpretation of the coefficients of those variables.

¹⁹ These mathematical facts and the reasons for them are clearly stated in many leading texts on regression mathematics. SEE FOR EXAMPLE: Neter, John, Michael H. Kutner, Christopher J. Nachtsheim, William Wasserman, "Applied Linear Regression Models," Third Edition, Irwin, New York, 1996. With respect to the last assumption, for example see page 9. "The existence of a statistical relation between the response variable Y and the explanatory or predictor variable X does not imply in any way that Y depends causally on X. No matter how strong is the statistical relation between X and Y, no cause-and-effect pattern is necessarily implied by the regression model."

²⁰ Wolverton, Marvin L., PhD, MAI, and Steven C. Bottemiller, MAI, "Further Analysis of Transmission Line Impact on Residential Property Values," *The Appraisal Journal*, July, 2003, p 244.

ing the influence of high voltage power lines on proximate property values, absolutely none of the papers studied showed any indication that an appropriate test of the null had been performed. In a test of the null by this author in a situation where detrimental condition theory would indicate a high likelihood of an impact on value to proximate properties the null could not be rejected.²¹

It would appear that researchers have assumed an influence and then employed hedonic modeling or predictive regression to allegedly measure that assumed influence. Unfortunately, hedonic modeling and predictive regression are generally incapable of performing such measurement and certainly are incapable of demonstrating that such an influence exists.

Hedonic Modeling

Hedonic modeling is an econometric technique that makes three critical economic assumptions concerning the interpretation of the results of regression mathematics. Specifically: 1) That the coefficients of the predictor variables hypothesized by the regression model are quantitatively meaningful; 2) That the value of a predictor variable coefficient represents the marginal contribution of that specific variable to the response, and; 3) That a sufficiently large result of a test of significance of a specific predictor variable coefficient indicates a meaningful cause and effect relationship between the hypothesized predictor variable and the response. These three key assumptions by the economist supporting hedonic modeling are mathematically unsupported, particularly for observational (real world) data.

With respect to the quantitative meaning of the predictor variable coefficients, and the related interpretation of those coefficients as the marginal contribution of that predictor variable to the response, these assumptions are true if—and only if—all of the predictor variables have been included in the regression and the predictor variables are absolutely independent of each other. These conditions may be obtainable in a carefully designed laboratory experiment, but the probability of their occurrence for real world observational data is vanishingly small. Any relationship between the included and/or omitted predictor variables or any overall relationship not explicitly addressed by the regression (e.g. "location" in its many real estate related facets), compromise the assumption of independence.

The assumption by economists that a positive test for significance of the coefficient demonstrates causality has already been addressed: It does not and cannot. Further, there is a curious tendency on the part of many researchers to indicate that to achieve significance they had to reduce the number of predictor variables in the regression. They seem to fail to realize that the apparent increase in significance²² results from omitted variables contributing to the coefficient of the remaining

predictor variables. The problem is then: Which omitted variables are contributing and how much are they contributing? The included predictor variable no longer represents just itself but also some portion of all of the contributing omitted variables. This question is virtually unanswerable.

Further, there is no "correct" hedonic model nor, to this author's knowledge, any means of identifying a "correct" model from the many thousands of possible models. Put simply, hedonic modeling is a "rubber ruler" that may be manipulated to achieve almost any desired result. As such it is a highly unreliable, if not a deliberately deceptive analytical tool.

It is notable that hedonic modeling is not a technique recognized by mathematicians dealing with regression. In an examination of 21 texts written by mathematicians for mathematicians or attorneys the word hedonic or related phrases cannot be found in their indices. On the other hand (to use an economic expression) there is a great deal of discussion in those books of the reasons why such a model would be unreliable.

Predictive Regression

This technique is the prediction of a new response using the hedonic model's regression equation, sometimes with some of the predictor variable coefficients in the original regression model set to zero in an improper (mathematically and economically) attempt to predict an "unimpaired" value or sale price. The phrase "predictive regression" is misleading—no new regression is performed.

The use of this procedure displays an unfortunately high degree of misunderstanding of regression mathematics. A regression relationship will provide a point estimate of the expected value of the response, but that point estimate can only be understood in the context of the confidence interval of values surrounding it. The breadth of the confidence interval (the measure of the precision of the prediction) is dependent on three factors: (1) The magnitude of the variance associated with the regression; (2) The departure of the specific values used for the predictor variables from the mean value of those variables in the data base upon which the regression was performed, and; (3) Whether or not the point estimate concerns a datum from within the regression database or is an estimate of a new value (i.e. new circumstances of sale or a new property).

The first thing to note is that the confidence interval for the prediction of a new point (i.e. one not within the database, a new sale) is larger than the confidence interval for the prediction of a sale contained in the database by the t-value for the desired confidence limit times the standard deviation (the square root of the variance). If the standard deviation is large relative to the mean value of a sale within the database then the accuracy of prediction will be very poor (by approximately twice the standard deviation at the 95% confidence level). This point seems to generally be ignored by researchers using this technique.

In *UST Effects*, the mean price of the 16,990 properties in the database was reported as \$86,535 and the standard deviation as \$64,481. Note that this large standard deviation is almost certainly a consequence of a failure to perform thorough external and internal validation and editing/selection procedures. For the $\alpha = 0.05$ confidence interval on a new prediction, assuming it is a property identical in every respect to the mean

²¹ Wilson, Albert R., "Proximity Stigma: Testing the Hypothesis," forthcoming.

²² Significance in the literature is normally measured by the so-called student's t-test, significance being achieved when the t-test value exceeds some value—usually 1.96 for the 95% confidence level. There are a number of mathematical and practical reasons why (a) the t-test is probably inaccurate for most regressions and (b) why a 95% confidence level is wholly insufficient for economic reasons.

property in the database used to develop the regression (the point of maximum accuracy of prediction), the confidence interval would be more than $\pm \$126,386$. Since this confidence interval includes zero, the prediction will be essentially nonsense.

Some of the *Pipeline Rupture* issues have already been discussed including external and internal validation errors and errors in methodology. What is significant for this paper is the admission in sworn testimony by the principal author a few weeks after the article appeared in *The Appraisal Journal* that—after correction of some analytical errors—the results of the paper could no longer be supported. This fact has never been published in *The Appraisal Journal*. As far as a reader would know, this article is still an acceptable “peer reviewed” article on which some degree of reliance may be placed.

Summary and Recommendations

There are a series of major problems with the existing “peer reviewed” real-estate literature.

On the part of the authors the problems include:

- 1) Failure to employ proper data validation and editing techniques.
- 2) Failure to use the appropriate analysis methodologies for the problem being addressed.
- 3) Failure to understand the limits of the analytical techniques and methodologies used.
- 4) Failure to publish as a part of the article the appropriate statistical information that will identify the precision, accuracy and reliability of their analysis to the reader.
- 5) Failure in their responsibility to clearly identify mistakes to the publisher once they have been recognized.

Problems on the part of reviewers included:

- 1) Failure to recognize violations of fundamental requirements for data validation and editing.
- 2) Failure to recognize or understand the economics and dynamics of real estate values.
- 3) Failure to recognize or understand the mathematics employed.

On the part of editors the primary problem is a failure to provide a sound mechanism for the correction of erroneous articles or information. The “letters to the

editor” methodology is wholly insufficient as a means to accomplish this. In addition there appears to be a failure to appropriately select reviewers knowledgeable in all the fields concerned with a specific submission. Sending an article to just an urban economist when that article uses significant information in the field of real estate valuation or mathematics is probably a mistake as the urban economist does not generally appear to have the requisite background knowledge.

Given the foregoing it is unreasonable for anyone to place significant reliance on the “peer reviewed” literature, at least in that segment examined as a part of this research. It is highly unreliable.

To improve reliability, the following suggestions appear to be the minimum requirements of an editorial peer review policy.

- 1) State that the articles are “Editorially Peer Reviewed.” An unqualified statement of “peer review” is inappropriate and misleading.
- 2) Clearly state what does and does not constitute “Editorial Peer Review.”
- 3) Require that all authors using large collections of data as the basis for their analysis preserve those databases for a reasonable period of time and make them available to any qualified researcher upon request and—if appropriate—payment of reasonable duplication costs. This should include a detailed description of validation, editing, selection and mathematical procedures sufficient to allow another researcher to replicate the author’s analysis.
- 4) Require that if the author discovers errors in a previously published article they notify the publication upon such discovery.
- 5) That the publication undertake to publish articles refuting the analysis of earlier articles, not as “letters to the editor” but as articles subjected to the same “Editorial Peer Review” process as any other article.

While these suggestions will not lead to articles that may be thought of as having received a “true peer review,” they should at least provide the consumer with a reasonable and fair opportunity to form a judgement concerning the reliability and accuracy of the paper. Absent such information the only sound policy for a reader would be to consider all articles and their conclusions highly suspect and proceed in their use with great caution. Certainly such literature cannot be considered a reliable basis for any conclusions regarding the acceptance of a position or analysis in court.