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Advanced Statistical Modeling In Real Estate Appraisal

John A. Kilpatrick, Ph.D., MAI

August 2, 2012

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An Exploratory Review of the Effects of Toxic Mold on Real Estate Values

by Robert A. Simons, PhD, and Ron Throupe, PhD

abstract

This article reports outcomes of ten litigated toxic mold cases; a contingent valuation (CV) analysis of toxic mold in South Carolina; and mold case studies of an apartment complex near Seattle

Despite widespread recent interest in toxic mold, real estate literature has provided limited guidance on valuation issues for properties affected by it.

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CONSTRUCTION DEFECTS AND STIGMA

Published in

Mealey's Construction Defects

July, 2003

John A. Kilpatrick, Ph.D, Managing Partner
Mundy Associates LLC
Seattle, Washington 98109

Abstract

Properties suffering from construction defects exhibit a diminution in value resulting from both the actual cost to cure as well as the residual stigma losses. In the unremediated state, the sum of these should equal the diminution in market value, while post-remediation there is significant

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The Performance of Exterior Insulation Finish Systems and Property Value

Exterior insulation finish systems, or synthetic stucco, is a siding material used on a quarter of a million residences and several thousand commercial buildings in the United States, Canada, and Europe. EIFS use has been linked with moisture problems and structural rot in many buildings, necessitating value impact estimates by appraisers. The value estimates, which may require outside expertise in accordance with Advisory Opinion 9 of the *Uniform Standards of Professional Appraisal Practice*, include cost to cure and stigma. For residential appraisals, stigma may be estimated with matched pairs. For a commercial appraisal, stigma takes the form of an increased capitalization rate.

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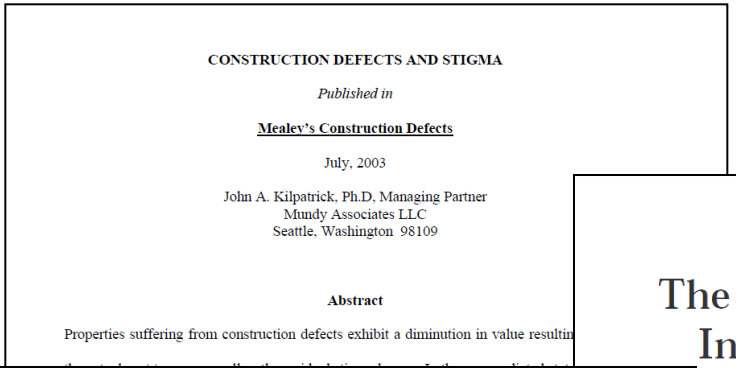

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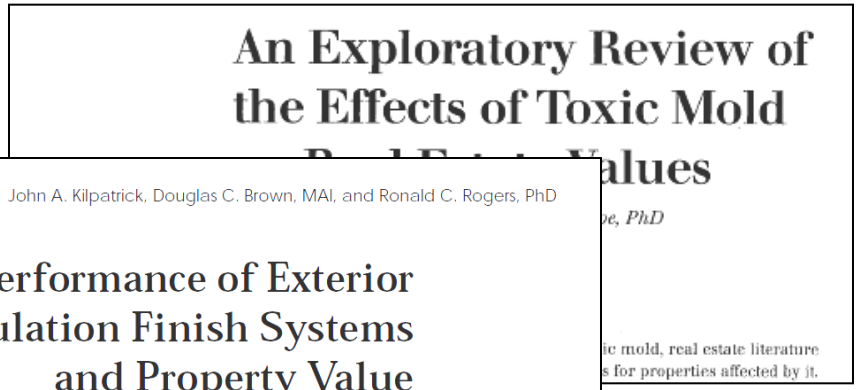

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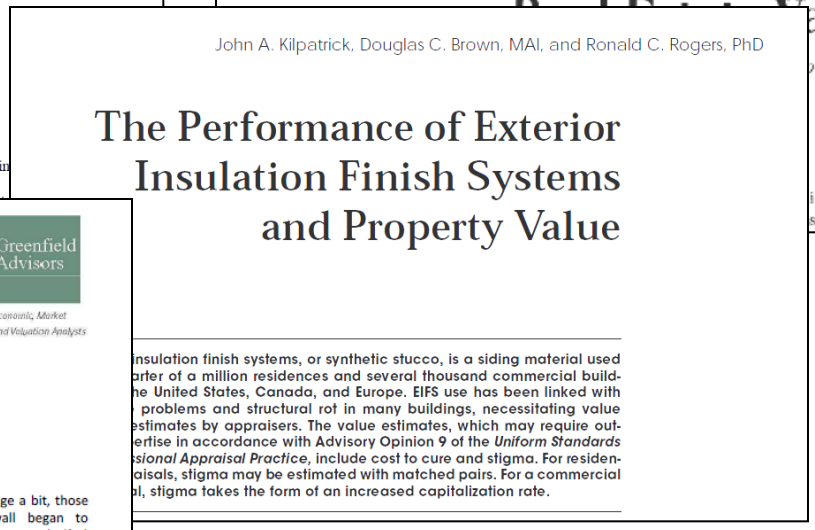

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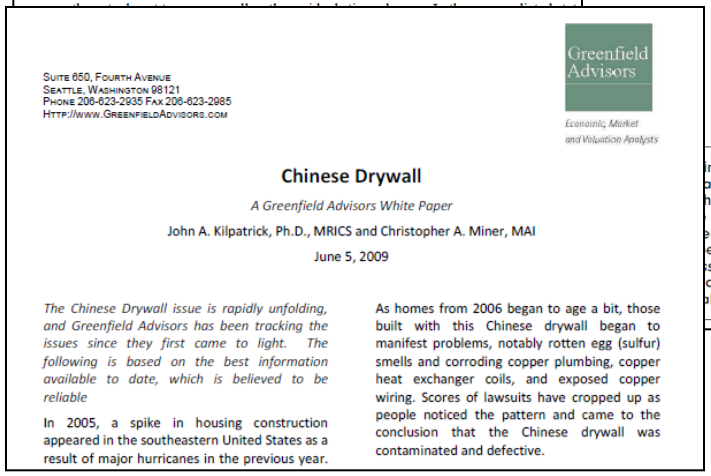

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Chinese Drywall

A Greenfield Advisors White Paper

John A. Kilpatrick, Ph.D., MRICS and Christopher A. Miner, MAI

June 5, 2009

The Chinese Drywall issue is rapidly unfolding, and Greenfield Advisors has been tracking the issues since they first came to light. The following is based on the best information available to date, which is believed to be reliable

In 2005, a spike in housing construction appeared in the southeastern United States as a result of major hurricanes in the previous year.

As homes from 2006 began to age a bit, those built with this Chinese drywall began to manifest problems, notably rotten egg (sulfur) smells and corroding copper plumbing, copper heat exchanger coils, and exposed copper wiring. Scores of lawsuits have cropped up as people noticed the pattern and came to the conclusion that the Chinese drywall was contaminated and defective.

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Bill Mundy, MAI, PhD

The Impact of Hazardous Materials on Property Value

Public opposition to the handling, storage, or disposal of hazardous materials in proximity to human or wildlife populations is high. How to safely deal with such hazardous materials is thus becoming a significant national issue. The impact of hazardous materials on property value is difficult to measure, however. While some models of real and perceived risk exist, to integrate them with actual market behavior is problematic. A theory of how contamination influences value that incorporates the damage related to lost income as well as the damages incurred by the lost opportunity to fully use a property is presented in this article. In addition, the effects of both the uncertainty concerning a particular hazard and the persistence of a perceived risk over time and distance are considered.

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THE FUTURE OF REAL ESTATE INFORMATION

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EVOLUTION OF REAL ESTATE STANDARDS

"I don't see information technology as a stand-alone system. I see it as a great facilitator. And maybe more important, it is a reason to keep asking yourself the question – why, why, why."

- Paul O'Neill, former Chairman and CEO of Alcoa, now U.S. Treasury Secretary[1]

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The Impact of Transit Corridors on Residential Property Values

Authors John A. Kilpatrick, Ronald L. Throupe, John I. Carruthers, and Andrew Krause

Abstract Most of the literature on transit corridors, such as superhighways and tunnels, focuses on the positive externality of transit access (e.g., interstate access, transit station) and fails to isolate the negative externality of the corridor itself. This empirical study examines two situations: one with both access benefits and negatives, and another without the access benefit. The findings reveal that proximity to the transit corridor alone without direct access conveys a negative impact on nearby housing values.

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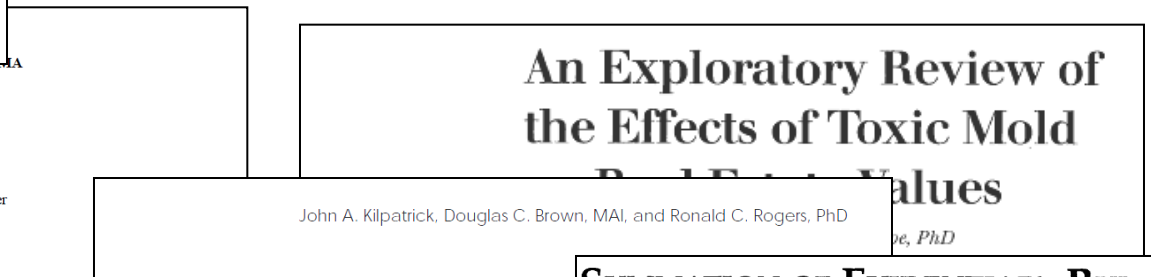

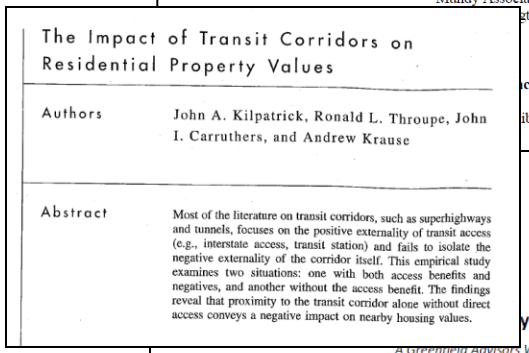

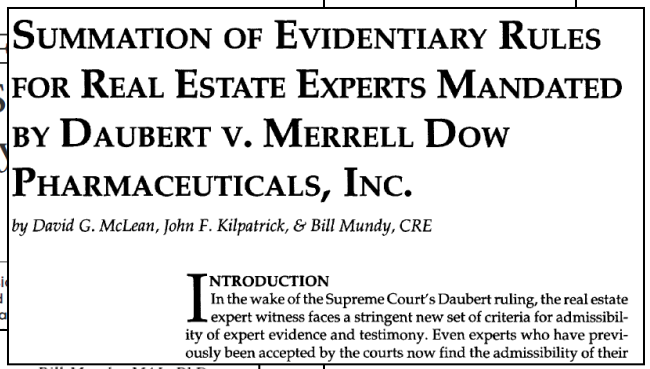

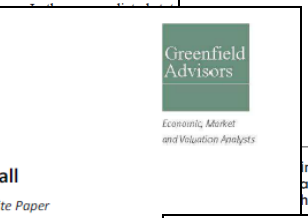

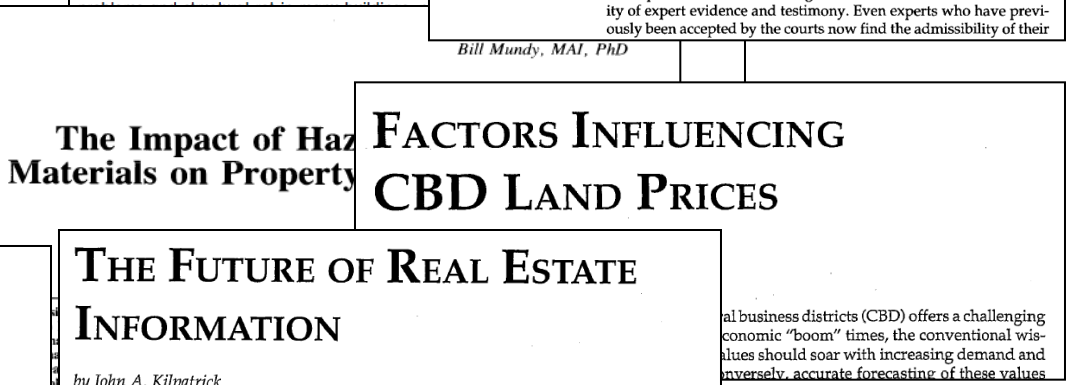

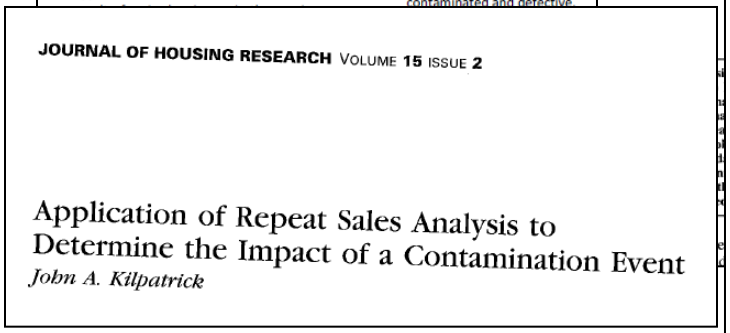

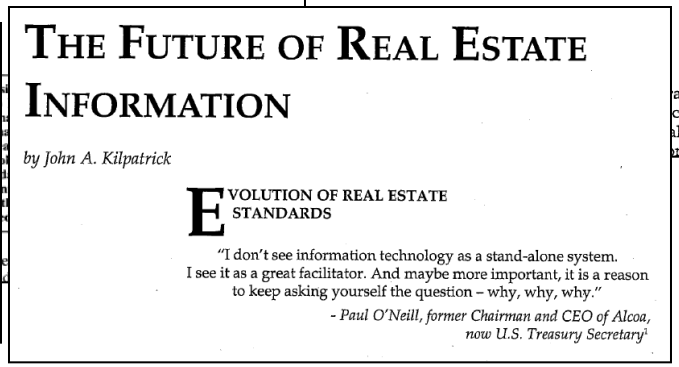

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How does this comport with USPAP and CPE?

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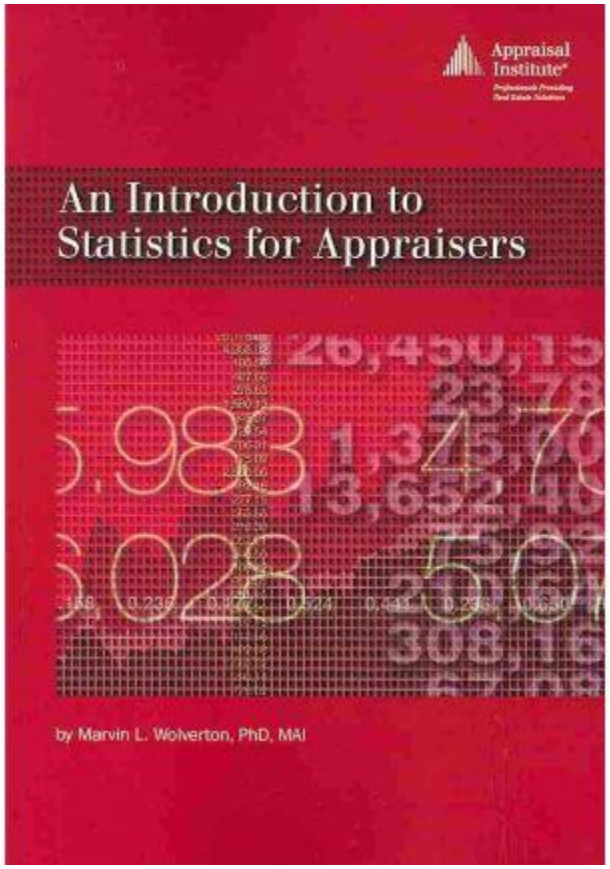

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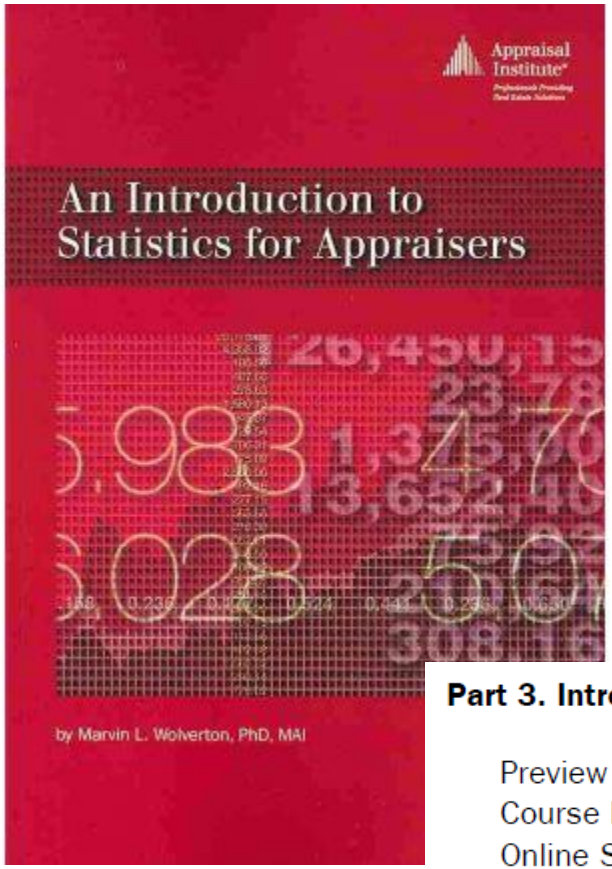

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NOT focused on litigation

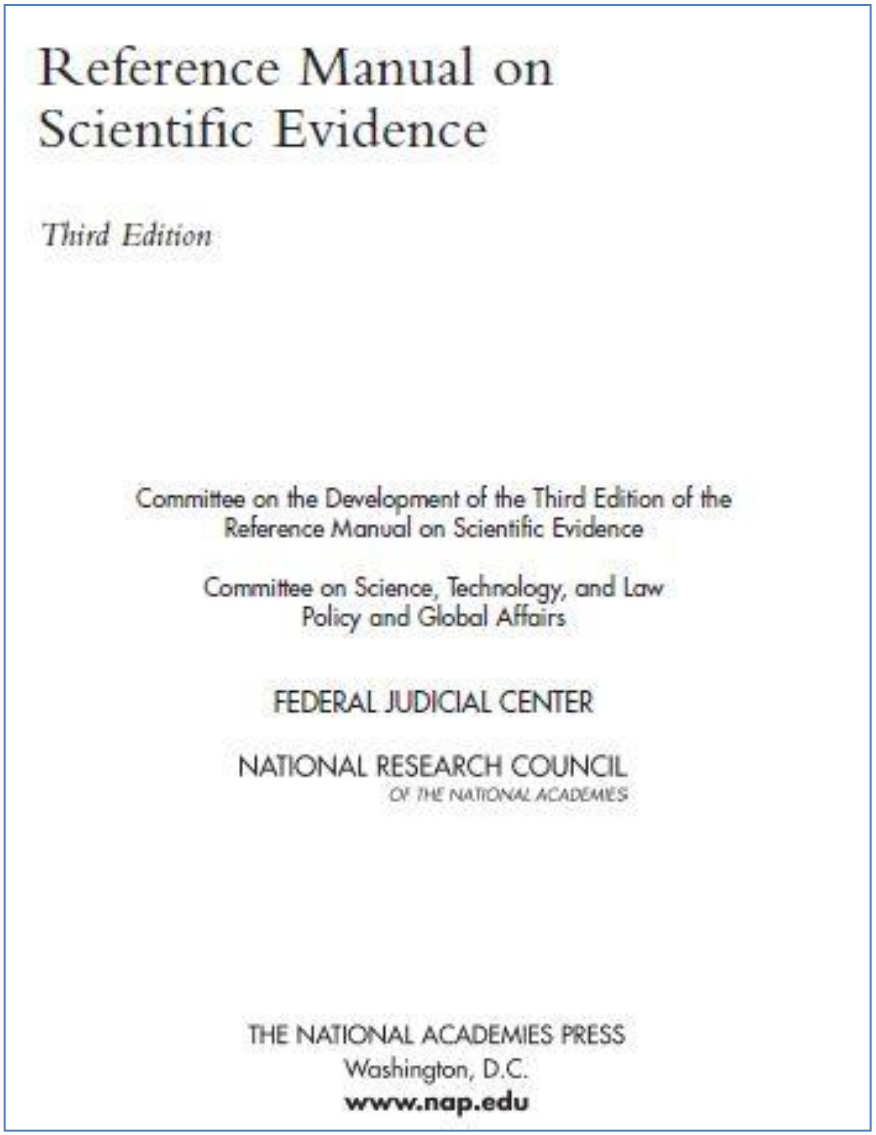
NOT introducing new topics

-- everything in this course is well established in the valuation literature

NOT trying to teach the AI's Quant Analysis Course

NOT trying to debate USPAP or CPE

-- these methods are all well established in USPAP and in the Code of Professional Conduct



Reference Manual on Scientific Evidence

Third Edition

Committee on the Development of the Third Edition of the Reference Manual on Scientific Evidence

Committee on Science, Technology, and Law
Policy and Global Affairs

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MODULE 4

Why Is Knowledge of Regression Useful to the Appraiser?

Learning about regression is increasingly important. As computing technology advances and data becomes more available, the regression model and other statistical techniques become more accessible and usable. And not surprisingly, over the past decade the number of appraisers using regression has increased dramatically. Thus even if you do not use regression, there is likely to be a time in the future when you will be looking at the work of someone else who has used the regression model. One group that uses regression extensively is tax assessors, who are charged with estimating the values of large numbers of properties. They have found that the use of models such as regression make the task reasonable in terms of time and cost.

Almost everyone in the appraisal and mortgage lending industries has heard of automated valuation models. Some people may not realize that regression is often at the core of these models. Recent estimates are that 20% - 30% of residential valuations are now being done using regression models, most in response to the preferences of mortgage lenders. That being the case, one can argue that regression has now become mainstream and is a recognized method or technique. Note that the Competency Rule and USPAP Standard 1 have particular relevance, because they require that appraisers be aware of, understand, and correctly employ recognized methods and also have the necessary knowledge and experience to complete assignments correctly. In addition, Standard 6 restates Rule 1 with reference to mass appraisal.

Why Is Knowledge of Regression Useful to the Appraiser?

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The Hedonic Regression Model

Sometimes called a "hedonic pricing model"

- *Uses comparable prices in the same way as a sales adjustment grid*
- *Called "hedonic" because it measures the marginal prices of individual components that people enjoy*

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USPAP? – more at the end

Comment to Standards Rule 3-1(a)

Changes and developments in economics, finance, law, and society can have a substantial impact on the appraisal profession. To keep abreast of these changes and developments, the appraisal profession is constantly reviewing and revising appraisal methods and techniques and devising new methods and techniques to meet new circumstances. Each appraiser must continuously improve his or her skills to remain proficient in appraisal review.

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The Hedonic Regression Model

Advantages:

- *Statistically grounded*
- *Easy to test which variables are statistically and economically meaningful*
- *"Matched Pairs" to achieve marginal prices are embedded in the process*
- *Easy to test accuracy*

The Hedonic Regression Model

Disadvantages:

- *Requires a large set of comparable data*
- *Mathematically more difficult*
- *Less appraiser judgment*
- *(is this an advantage or disadvantage?)*
- *Can be difficult to explain*

The Hedonic Regression Model

What do we mean by "marginal prices"

- *Economic term*
- *The regression equivalent of the output of a matched pair*
- *In a linear regression, it's the coefficient*

The Hedonic Regression Model

What do we mean by "marginal prices"

Example:

Land value = $10,000 per acre

V = 10000X

Thus, the marginal price of an acre of land is $10,000

The Hedonic Regression Model

What do we mean by "marginal prices"

Example:

House Value = $150/SF

+ $1,000 for every bathroom > 2

-- $1,000 for every bathroom < 2

+ $2,000 if it has a garage

+ $2,000 if it has a fireplace

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The Hedonic Regression Model

What do we mean by "marginal prices"

Example:

V = Intercept + 150X + 1000 (B-2) + 2000G + 2000F

What is the marginal price of a fireplace?

The Hedonic Regression Model

Consider this equation again:

$$V = Intercept + 150X + 1000\,(B\text{-}2) + 2000G + 2000F$$

The Hedonic Regression Model

Consider this equation again:

V = Intercept + 150X + 1000 (B-2) + 2000G + 2000F

What's missing?

The Hedonic Regression Model

Consider this equation again:

V = Intercept + 150X + 1000 (B-2) + 2000G + 2000F

What's missing?

Unexplained Variance

The Hedonic Regression Model

Consider this equation again:

$$V = Intercept + 150X + 1000\,(B\text{-}2) + 2000G + 2000F + \varepsilon$$

The Greek Letter Epsilon

The Hedonic Regression Model

Some rules about epsilon (unexplained variance):

- *Normally distributed*
- *Mean of zero (indicates unbiasedness)*
- *Standard deviation of 1 (consistency)*

The Hedonic Regression Model

Some rules about epsilon (unexplained variance):

- *Normally distributed*
- *Mean of zero (indicates unbiasedness)*
- *Standard deviation of 1 (consistency)*

We'll return to these rules again in a minute:

- *Problems*
- *Solutions*

The Hedonic Regression Model

Consider this equation again:

$$V = Intercept + 150X + 1000\,(B\text{-}2) + 2000G + 2000F + \varepsilon$$

Intercept?

The Hedonic Regression Model

The Regression Intercept

- *A constant*
- *The value of the equation if all other factors were set to zero*

The Hedonic Regression Model

The Regression Intercept

- *A constant*
- *The value of the equation if all other factors were set to zero*

- *In a hedonic pricing model, can be thought of as the value of a lot in the subject neighborhood*

The Hedonic Regression Model

The Regression Intercept

- *A constant*
- *The value of the equation if all other factors were set to zero*

- *In a hedonic pricing model, can be thought of as the value of a lot in the subject neighborhood*
- *(not exactly statistically accurate)*

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The Hedonic Regression Model

Assume the following appraisal problem:

Comp #	Price	SF	# of baths	Garage?	Fireplace?
1	$185,000	1250	2	Yes	No
2	$190,000	1300	2	Yes	No
3	$195000	1400	3	No	Yes
4	$205,000	1450	3	No	Yes
5	$220,000	1500	2	Yes	Yes
Subject	?	1400	2	Yes	No

	A	B	C	D	E	F	G	H	I
1	Price	sf	bath	gar	fp				
2	185000	1250	2	1	0				
3	190000	1300	2	1	0				
4	195000	1400	3	0	1				
5	205000	1450	3	0	1				
6	220000	1500	2	1	1				
7									
8	SUMMARY OUTPUT								
9									
10	*Regression Statistics*								
11	Multiple R	0.99593329							
12	R Square	0.99188312							
13	Adjusted R Sc	-0.0324675							
14	Standard Erro	2500							
15	Observations	5							
16									
17	ANOVA								
18		*df*	*SS*	*MS*	*F*	*Significance F*			
19	Regression	4	763750000	190937500	40.7333333	#NUM!			
20	Residual	1	6250000	6250000					
21	Total	5	770000000						
22									
23		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
24	Intercept	-12500	60104.0764	-0.2079726	0.86946136	-776194.7	751194.7	-776194.7	751194.7
25	sf	150	50	3	0.20483276	-485.31024	785.310237	-485.31024	785.310237
26	bath	0	0	65535	#NUM!	0	0	0	0
27	gar	8750	4841.22918	1.80739223	0.32172249	-52763.649	70263.6492	-52763.649	70263.6492
28	fp	-1250	11659.2238	-0.1072113	0.93200691	-149394.48	146894.485	-149394.48	146894.485

The Hedonic Regression Model

Consider this equation again:

$$V = -12{,}500 + 150X + 0B + 8750G - 1250F$$

$$V = -12{,}500 + 150(1400) + 0(2) + 8750(1) - 1250(1)$$

$$V = \$205{,}000$$

The Hedonic Regression Model

Consider this equation again:

$V = -12{,}500 + 150X + 0B +$

$V = -12{,}500 + 150(1400) +$

$V = \$205{,}000$

How much confidence do we have in this answer?

	A	B	C	D	E	F	G	H	I
1	Price	sf	bath	gar	fp				
2	185000	1250	2	1	0				
3	190000	1300	2	1	0				
4	195000	1400	3	0	1				
5	205000	1450	3	0	1				
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Notice the difference between R^2 and adjusted R^2

	A	B	C	D	E	F	G	H	I
1	Price	sf	bath	gar	fp				
2	185000	1250	2	1	0				
3	190000	1300	2	1	0				
4	195000	1400	3	0	1				
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Notice the meaningless t- and p-statistics

	A	B	C	D	E	F	G	H	I
1	Price	sf	bath	gar	fp				
2	185000	1250	2	1	0				
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Notice the meaningless F-statistic

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Even though we get "unbiased" answers, the results are meaningless and lack validity, largely as the result of a small data set

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	A	B	C	D	E
1	Price	sf	bath	gar	fp
2	185000	1250	2	1	0
3	190000	1300	2	1	0
4	195000	1400	3	0	1
5	205000	1450	3	0	1
6	220000	1500	2	1	1
7	211400	1364	2	0	1
8	213400	1358			
9	230100	1499			
10	227300	1484			
11	201000	1307			
12	199500	1301			
13	225400	1450	3	1	0
14	215700	1389	2	0	1
15	205500	1339	2	0	0
16	212000	1381	2	0	1
17	231600	1488	2	1	1
18	219400	1415	3	1	1
19	226400	1464	2	1	0
20	223400	1443	3	0	0

This data set goes on for 100 comp sales

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.926102954
R Square	0.857666682
Adjusted R Square	0.8516737
Standard Error	3876.550144
Observations	100

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	8602533703	2.2E+09	143.112	2.527E-39
Residual	95	1427625897	1.5E+07		
Total	99	10030159600			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-3996.20597	9535.782453	-0.41907	0.67611	-22927.1272	14934.71525	-22927.1272	14934.7153
sf	155.1886764	6.83583455	22.7022	3.7E-40	141.6178293	168.7595234	141.6178293	168.759523
bath	483.8462186	784.148651	0.61703	0.53869	-1072.88564	2040.578077	-1072.88564	2040.57808
gar	2105.047687	797.2185058	2.64049	0.00968	522.3688867	3687.726487	522.3688867	3687.72649
fp	1225.677281	788.087123	1.55526	0.12321	-338.8734327	2790.227996	-338.8734327	2790.228

SUMMARY OUTPUT

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Note the negative sign for the intercept – we'll deal with that in a minute!

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.926102954
R Square	0.857666682
Adjusted R Square	0.8516737
Standard Error	3876.550144
Observations	100

Note the more meaningful range of adjusted R^2

ANOVA

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SUMMARY OUTPUT

Regression Statistics	
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Standard Error	3876.550144
Observations	100

F-test shows that the regression is valid

ANOVA

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Not all t-stats and p-values are in line, but the results are meaningful and have expected signs

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.96652375
R Square	0.93416816
Adjusted R Square	0.9328108
Standard Error	2221.9299
Observations	100

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	6795501171	3.4E+09	688.226	4.94477E-58
Residual	97	478886328.9	4936972		
Total	99	7274387500			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2846.25638	5639.687398	0.50468	0.61493	-8346.96169	14039.4744	-8346.96169	14039.47444
sf	147.586653	4.084140551	36.1365	4.5E-58	139.4807644	155.692541	139.480764	155.6925409
gar	2131.78978	448.0471278	4.75796	6.8E-06	1242.540282	3021.03928	1242.54028	3021.039284

We can “bootstrap” the process by eliminating the variables that don’t have meaningful results

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.96652375
R Square	0.93416816
Adjusted R Square	0.9328108
Standard Error	2221.9299
Observations	100

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	6795501171	3.4E+09	688.226	4.94477E-58
Residual	97	478886328.9	4936972		
Total	99	7274387500			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2846.25638	5639.687398	0.50468	0.61493	-8346.96169	14039.4744	-8346.96169	14039.47444
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Now, adjusted R^2 is improved and the intercept has the expected sign

The Hedonic Regression Model

Now, what does our equation look like?

$$V = 2846 + 148(SF) + 2132(G)$$

$$V = 2846 + 148(1400) + 2132(1) = \$212,178$$

(earlier answer was $205,000)

The Hedonic Regression Model

One more improvement:

Ln(V) = Intercept + Coefficients X Ln(factors)

Why?

The Hedonic Regression Model

Using logarithms is called a log- or semi-log transformation

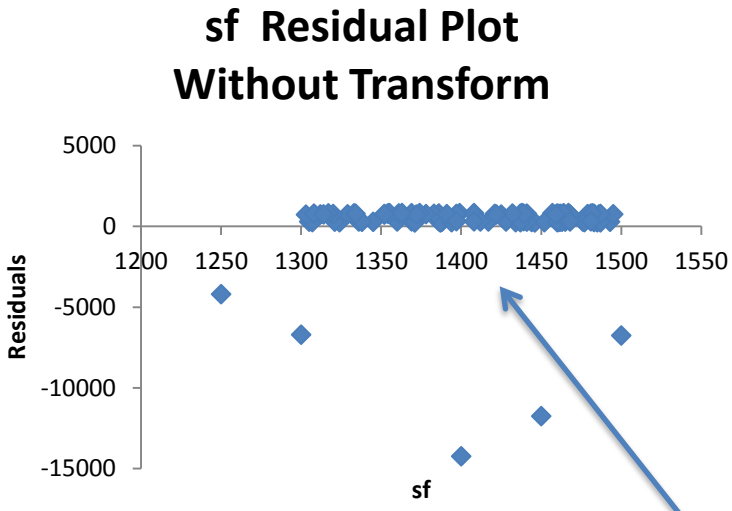
Sometimes called a Box-Cox transformation

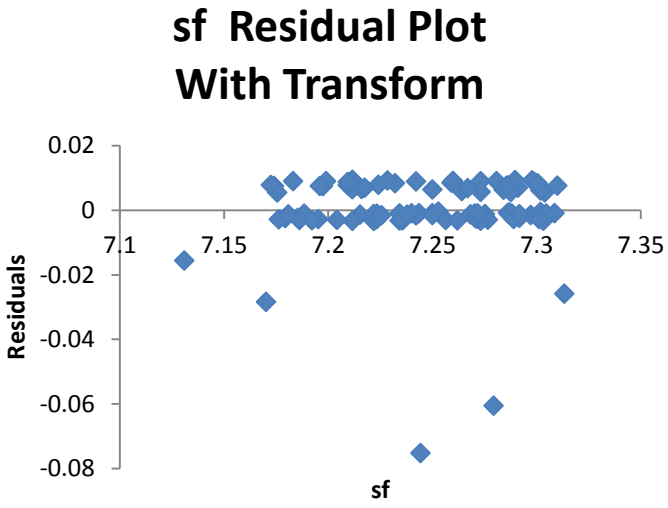
Remember that error terms are supposed to be ~N(0,1)?

Real estate prices are always > 0, so this rule may be violated

Log transformation corrects for this

The Hedonic Regression Model

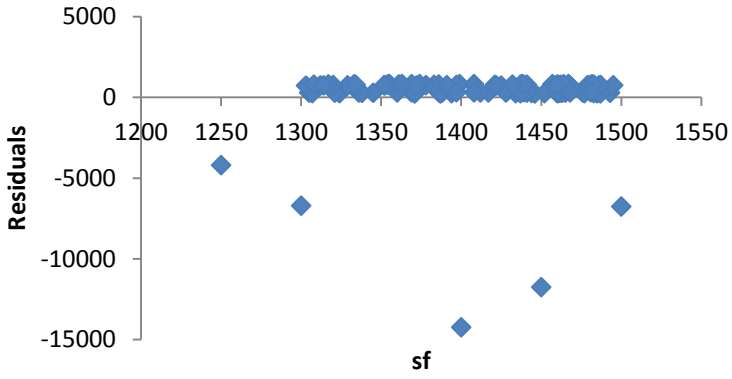




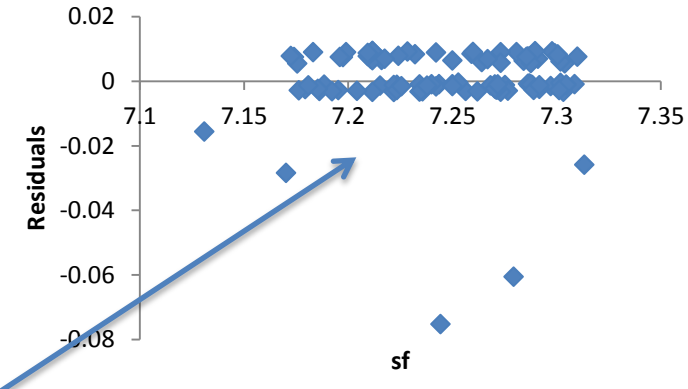
Without transform, residuals are biased

The Hedonic Regression Model

sf Residual Plot Without Transform



sf Residual Plot With Transform



With transform, residuals are unbiased

The Hedonic Regression Model

Transformed solution

V = Exp(Intercept + Coefficients X Factors)

= $210,686

(earlier answer was $212,178)

The Hedonic Regression Model

Transformed solution

V = Exp(Intercept + Coefficients X Factors)

= $210,686

This is the anti-log function

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The Hedonic Regression Model

Appraisal Standards?

Generally thought of under USPAP 6 (Mass appraisal, AVMs)

Hedonic modeling is fully consistent with USPAP 1

When conducting a mass appraisal, IAAO supplemental standards provide good guidance

Integrated with GIS, etc.

Need to cite either/or USPAP 1 and 6

The Hedonic Regression Model

Colwell, et al., TAJ 2009

Cites Rubenfeld, Reference Manual on Scientific Evidence

Cites In Re: Guardian Pipeline (Judge Frank Easterbrook)

Testifying expert should have training in both appraisal and statistical methods

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Hedonic Regression: "must read"

Colwell, et al., TAJ 2009

Rubenfeld, "Regression", in Reference Manual on Scientific Evidence, (U.S. DOJ, 2010)

Kauko & d'Amato, Mass Appraisal Methods (RICS, 2008)

Gloudemans, Mass Appraisal of Real Property (IAAO, 1999)

Wolverton, An Introduction to Statistics for Appraisers (A.I., 2009)

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Survey Research

Informal surveys

– *Market Research*

– *Rent/Cap Rate Surveys, etc.*

Formal surveys

– *Contingent Valuation*

– *Conjoint Measurement*

– *Perceived Diminution*

Survey Research

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- ***Contingent Valuation***
- *Conjoint Measurement*
- *Perceived Diminution*

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Survey Research

Common Uses:

When transactional data is insufficient or unreliable

- *Lack of transactions*
- *Transactions don't meet definition of value*
- *Market is at disequilibrium*

Survey Research

Common Uses:

When transactional data is insufficient or unreliable

- *Lack of transactions*
- *Transactions don't meet definition of value*
- *Market is at disequilibrium*

To supplement or support transactional data

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Survey Research

Two recent examples:

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Survey Research

Two recent examples:

Allison v. Exxon – survey research told a compelling story to the jury when transactional data was muddled in a drinking water contamination case

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Survey Research

Two recent examples:

Allison v. Exxon – survey research told a compelling story to the jury when transactional data was muddled in a drinking water contamination case

Rogers v. U.S. – explained and supported a transactions-based adjustment in a rails-to-trails taking

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Survey Research

"stated preference" versus "revealed preference"

Survey Research

"stated preference" versus "revealed preference"

*Transactional-based models (e.g. – sales comparison approach): the market participants **reveal** their preferences via the choices they make*

Survey Research

"stated preference" versus "revealed preference"

Transactional-based models (e.g. – sales comparison approach): the market participants reveal their preferences via the choices they make

*Survey research: market participants **state** their preferences directly*

Survey Research

"stated preference" versus "revealed preference"

Note that both are market perspectives and rely on market data.

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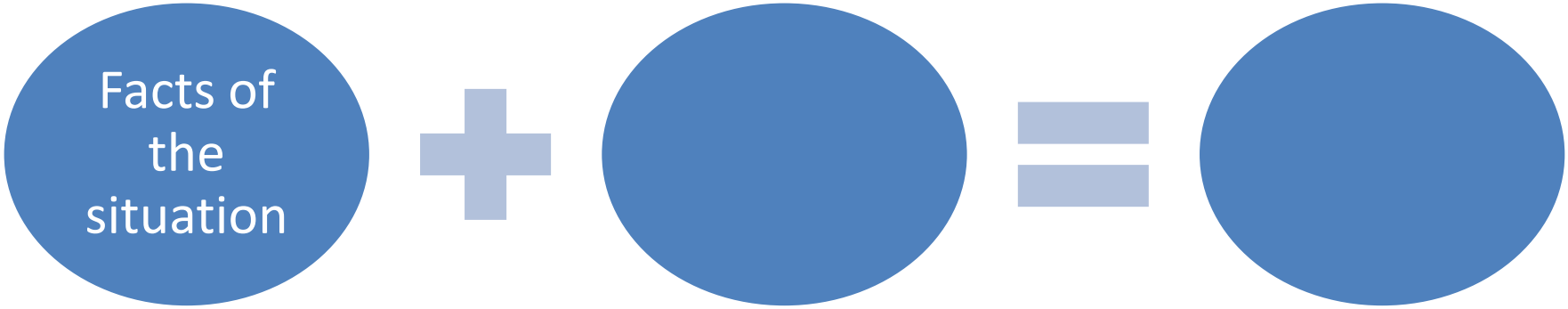

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Often referred to as a fact card, but may be photographs, a video, or other presentation.

Facts of the situation

+

R

In Rogers v. U.S., the "fact card" was actually a set of videos, much like a typical Realtor™ sales video. Alternate presentations of the video showed the yard with a trail and without a trail.

Often referred to as a fact card, but may be photographs, a video, or other presentation.

Important issues include large sample size, response rate, and unbiased format of the questions.

Follows well-accepted sampling methods, derived from market research and statistics.

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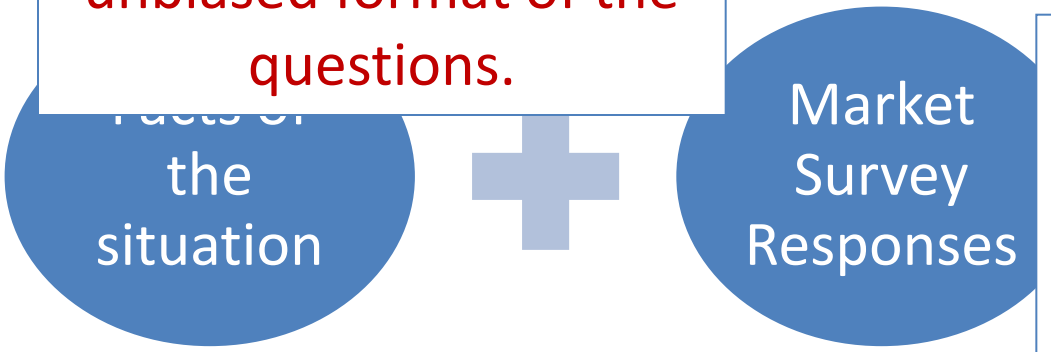
Important issues include large sample size, response rate, and unbiased format of the questions.



Increasing use of online surveys allows for very large samples, albeit with lower response rates, but improves selection bias.

Follows well-accepted sampling methods, derived from market research and statistics.

Survey Research - Advantages

One of the only ways to measure "non-use" values

- *Environmental impairment*
- *Both Goods (willingness to pay) and Bads (willingness to accept)*
- *Private impacts of public goods (airports, rails-to-trails, etc.)*

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Survey Research - Advantages

One of the only ways to measure "non-use" values

- *Environmental impairment*
- *Both Goods (willingness to pay) and Bads (willingness to accept)*
- *Private impacts of public goods (airports, rails-to-trails, etc.)*

Often referred to as "passive use" values

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Survey Research - Advantages

Enormously flexible

Widely used both in appraisal and other areas – well developed body of knowledge

Methodology outlined in the Reference Manual on Scientific Evidence published by the U.S. Justice Department

Results easy to analyze and describe – understandable and compelling to a Court

Survey Research - Challenges

1993 NOAA Panel – questions which have been answered

Confusing WTP with WTA

(Note: WTP has an implicit income constraint)

Confusing cross-sectional and longitudinal studies

Survey Research – "Must Read"

Diamond, "Survey Research", in Reference Manual on Scientific Evidence (U.S. DOJ, 2010)

Mundy and McLean, "Addition of CV to the Required Body of Knowledge", in J. Real Estate Practice and Education (ARES, 1998)

Lipscomb, Mooney, and Kilpatrick, "Do CV Results Systematically Differ from Hedonic Regression Results? Evidence From a Residential Property Meta-Analysis", J. Real Estate Literature, 2013

Meta Analysis

Question – how do we statistically compile the collected wisdom of scholars in the field?

Meta Analysis

Contrasting and combining results from different studies,

Identifying patterns among study results

Identifying sources of disagreement

Identifying other interesting relationships

Meta Analysis

One recent use -- to assess diminution in value resulting from environmental disamenities

Meta Analysis

Assume we have three published studies about groundwater contamination:

Study	# obs	% dim
1	30	25%
2	15	40%
3	25	45%

Meta Analysis

What if we took a weighted average of these studies?

Study	# obs	% dim	Weighted
1	30	25%	11%
2	15	40%	9%
3	25	45%	16%
Total	70		
average of 3 studies			35%

Meta Analysis

In reality, meta analyses look at dozens of studies, and control for such factors as type of contaminant (groundwater, air, etc.), geographic region, neighborhood type (rural, suburban, etc.), time factors, and underlying unimpaired property value.

Meta Analysis

In reality, meta analyses look at dozens of studies, and control for such factors as type of contaminant (groundwater, air, etc.), geographic region, neighborhood type (rural, suburban, etc.), time factors, and underlying unimpaired property value.

The exact control variables are less important than arriving at a good explanatory "fit"

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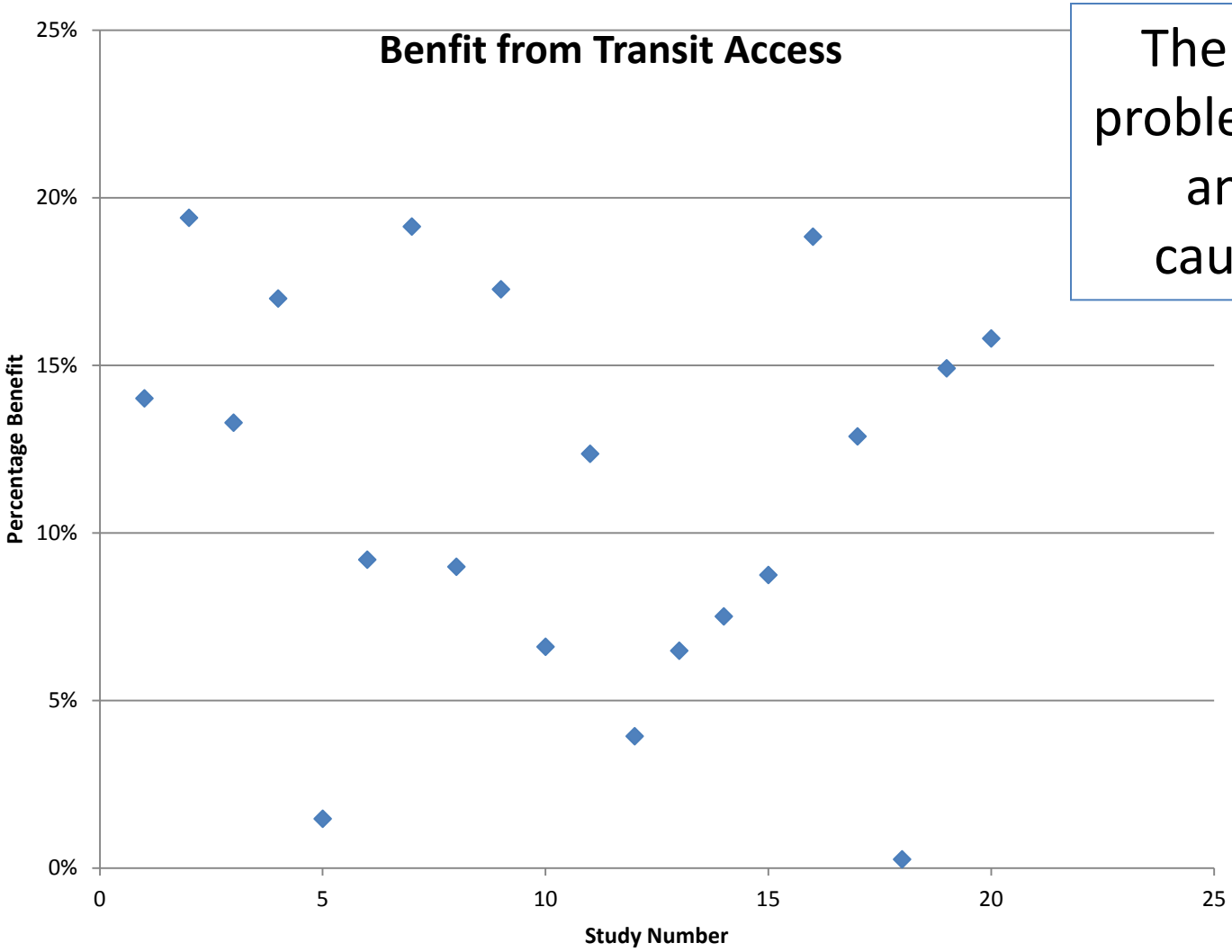

The “file drawer problem” with meta analyses -- a cautionary tale

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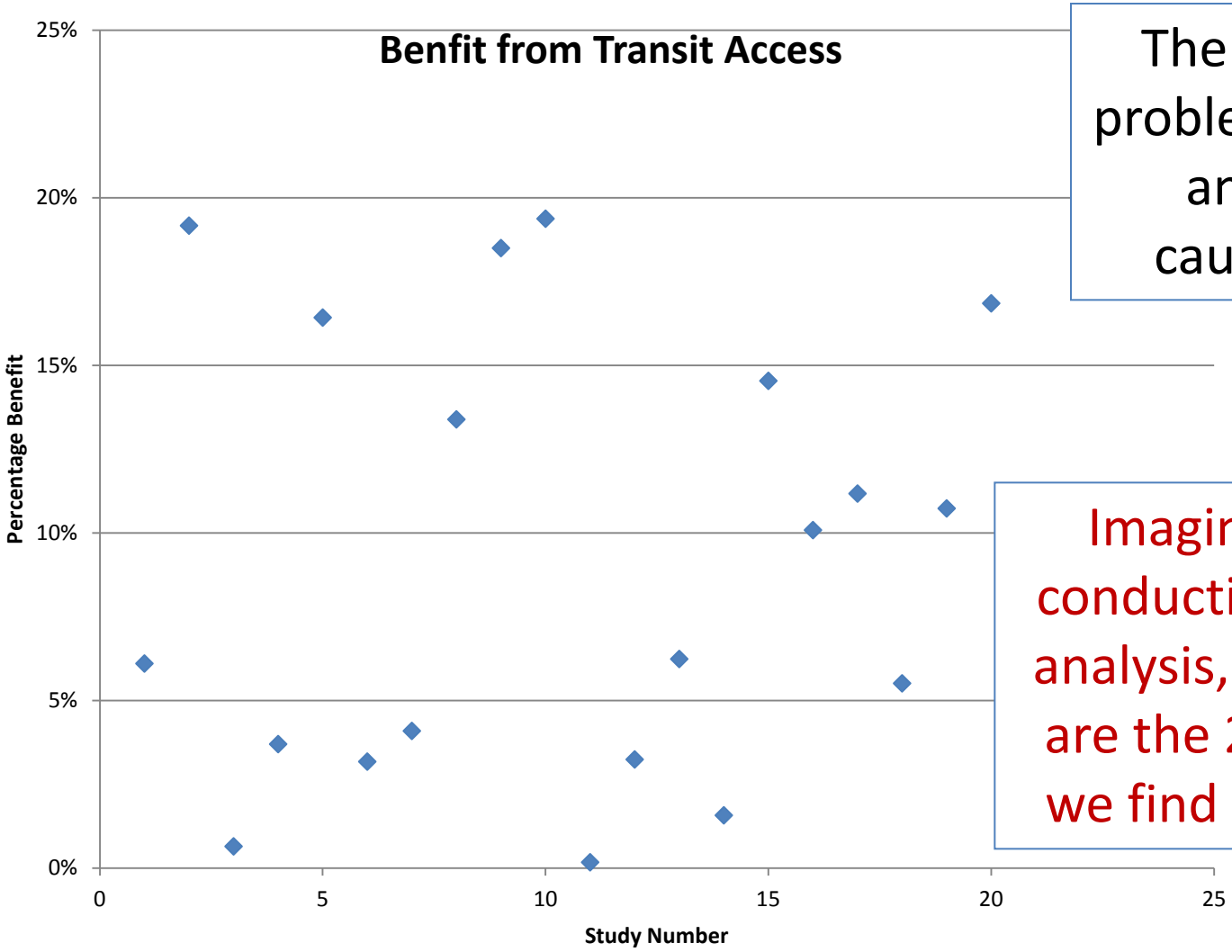

The "file drawer problem" with meta analyses -- a cautionary tale

Imagine we're conducting a meta analysis, and these are the 20 studies we find published

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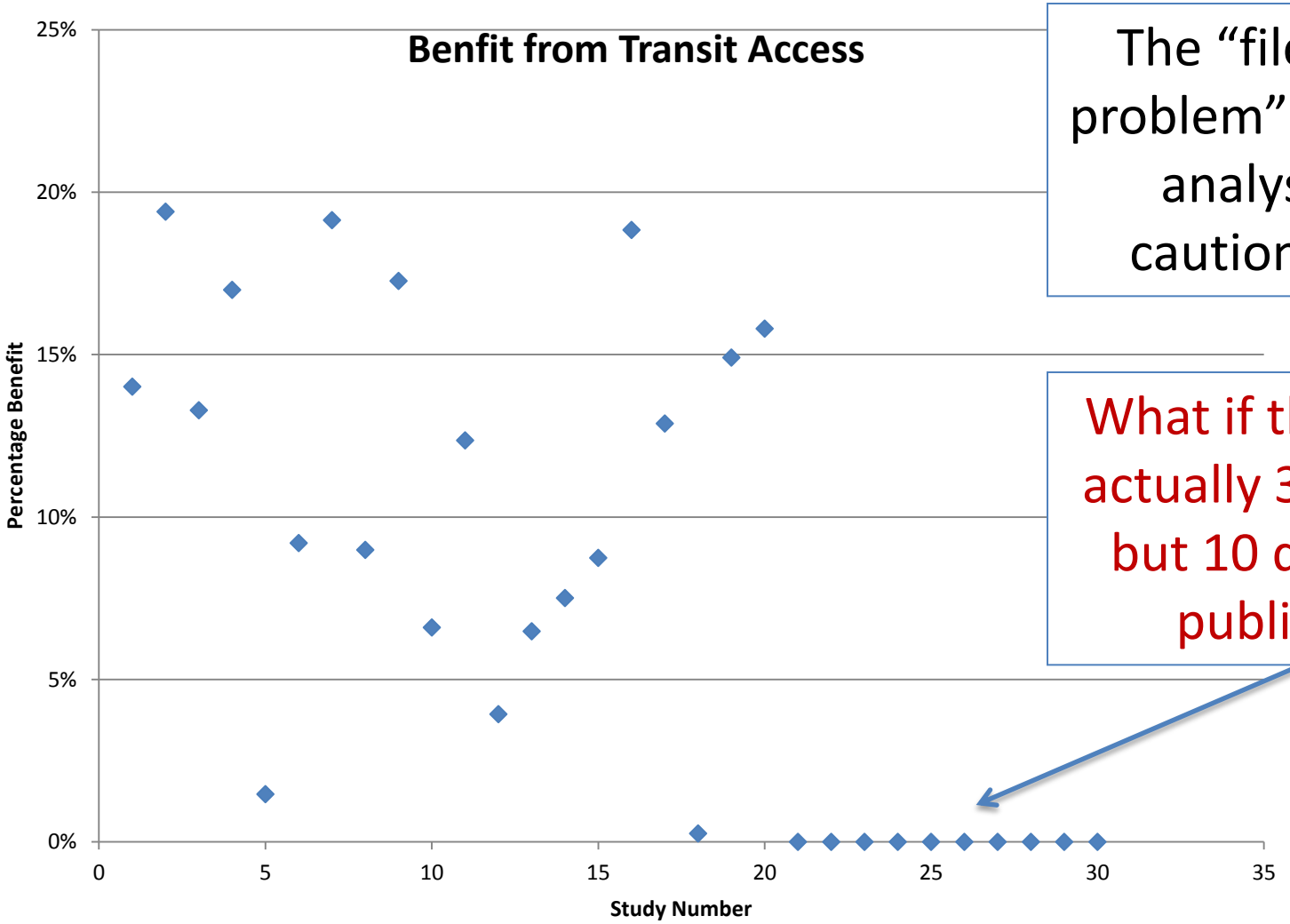

The "file drawer problem" with meta analyses -- a cautionary tale

What if there were actually 30 studies, but 10 didn't get published?

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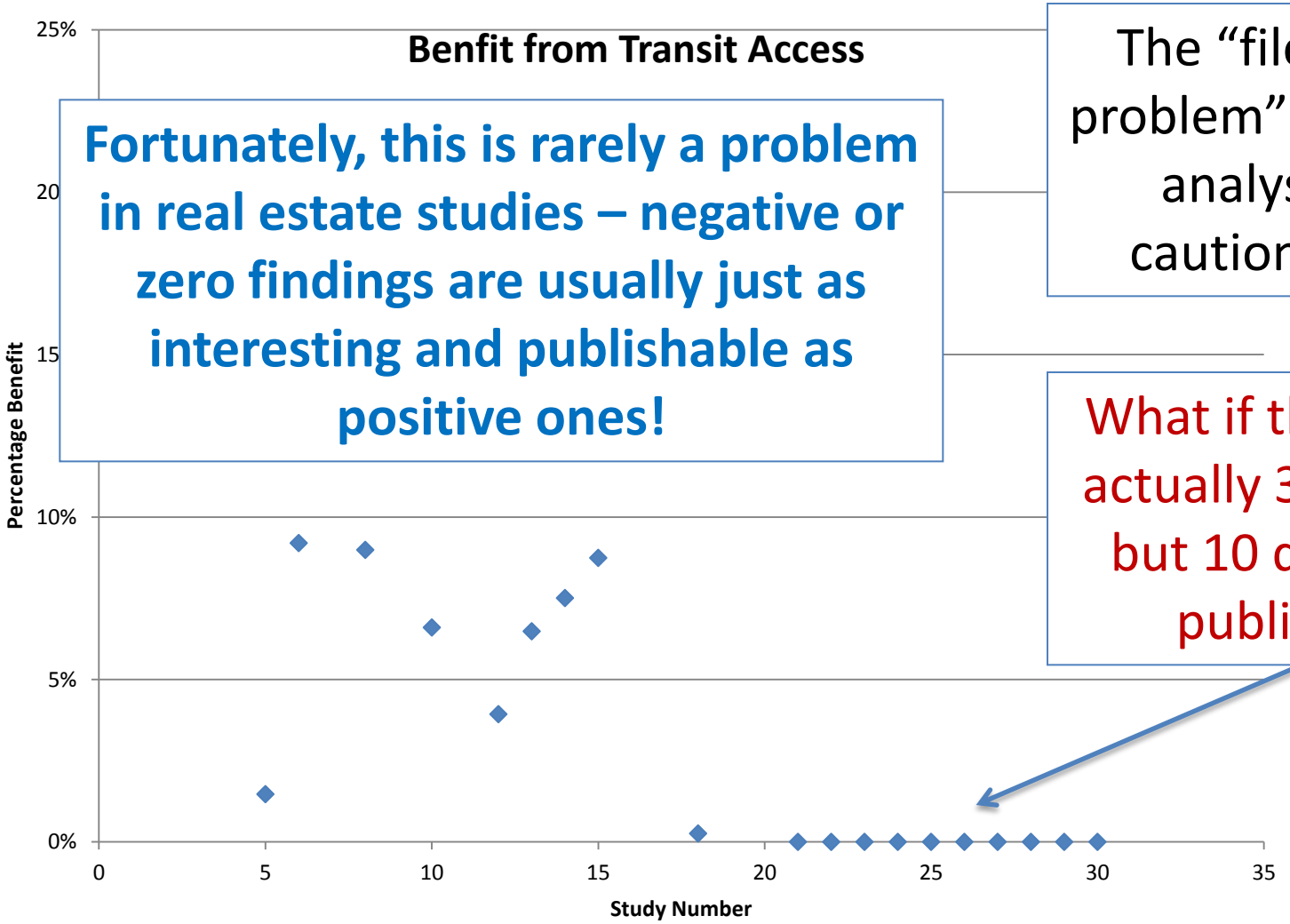

Fortunately, this is rarely a problem in real estate studies – negative or zero findings are usually just as interesting and publishable as positive ones!

The "file drawer problem" with meta analyses -- a cautionary tale

What if there were actually 30 studies, but 10 didn't get published?

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Meta Analysis

Usefulness?

- *Contaminated Property Litigation*
- *Housing Characteristics*
- *Real Estate Brokerage Effectiveness*
- *REIT & RE Portfolio Valuation*
- *Appraisal Accuracy*
- *Environmental Amenities*
- *Transportation Infrastructure & Airport Noise*
- *Historic Preservation*

Meta Analysis – "must read"

Simons & Saginor, J. Real Estate Research, 2006

Lipscomb, Mooney, & Kilpatrick, J. Real Estate Literature, forthcoming, 2013

Sirmans, MacDonald, Macpherson, & Zietz, National Center for R.E. Research, 2005

Debrezion, Pels, & Rietveld, J. Real Estate Finance & Economics, 2007

Nelson, J Transport Economics and Policy, 2007

Expert Systems

What happens "in between" the hedonic model and the sales adjustment grid?

Is there a way to bring the power of statistical analysis to smaller data sets or "dirty" data?

How can we incorporate the appraiser's "judgment" into statistical processes?

Expert Systems

Ties together several streams of research:

- *Statistics*
- *Appraisal Theory and Practice*
- *Set Theory*
- *Equilibrium Theory*

Expert Systems

But first a word about WLS – weighted least squares

OLS (ordinary least squares) only works if the error terms (the "residuals") are normally distributed with a mean of zero and a standard deviation of 1

What if the error terms are badly behaved?

Expert Systems

What could cause badly behaved errors?

Spatial colinearity

Temporal colinearity

Non-negative variables (i.e. – truncated prices)

Expert Systems

What could cause badly behaved errors?

Spatial colinearity

Temporal colinearity

Non-negative variables (i.e. – truncated prices)

These are all common in real estate data

Expert Systems

In a pure regression model, we accommodate this with what's called "weighted least squares"

Some uniform weighting is applied

Example – using a logarithmic adjustment in hedonic pricing models

Expert Systems

Hence, when we apply regression or other statistical modeling to the appraisal process, one challenge is to incorporate appraiser judgment to adjust for "non-normality" in the data.

Recall Colwell, et al. TAJ 2009 – both appraisal and statistics training are necessary in modeling

Expert Systems:

The Bayesian Estimator

$$\Pr(H \mid E) = \frac{\Pr(E \mid H)\Pr(H)}{\Pr(E)}$$

Expert Systems:

The Maximum Likelihood Estimator (MLE)

Given what we know about this data, what probability model fits best?

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Expert Systems:

The Maximum Likelihood Estimator (MLE)

Consistency: The MLE converges asymptotically to the value being estimated. From an appraisal perspective, this means that there is a benefit to experience and professionally developed judgment.

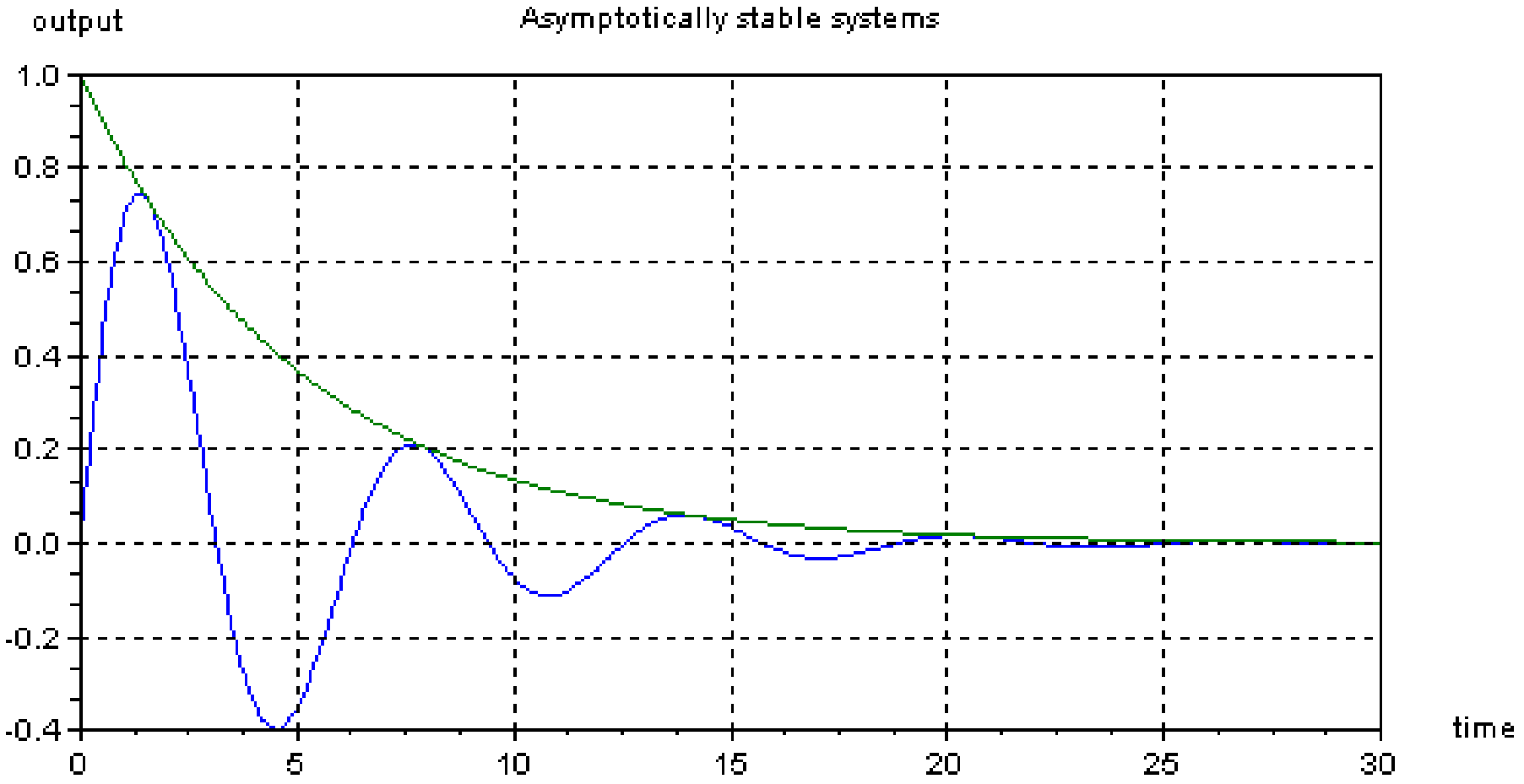
Expert Systems:

The Maximum Likelihood Estimator (MLE)

What do we mean by "asymptotic"?

As "N" gets larger and larger, the equation becomes more and more normal.

The Central Limit Theorem is an example of an asymptotic distribution



Expert Systems:

The Maximum Likelihood Estimator (MLE)

Asymptotic normality: As sample size increases, the MLE distribution tends toward a normal distribution.

Expert Systems:

The Maximum Likelihood Estimator (MLE)

Asymptotic normality: As sample size increases, the MLE distribution tends toward a normal distribution.

$$f(x) \sim N(as\, n \Rightarrow \infty)$$

Expert Systems:

The Maximum Likelihood Estimator (MLE)

Efficiency: There is no asymptotically unbiased estimator that has lower asymptotic mean square error.

Expert Systems:

The Maximum Likelihood Estimator (MLE)

So why don't we use MLE more often?

Expert Systems:

The Maximum Likelihood Estimator (MLE)

So why don't we use MLE more often?

$$\ln L(\Phi \mid x_1 \ldots x_n) = f(x_1 \ldots x_n \mid \Phi) = \sum_{i=1}^{n} \ln f(x_i \mid \Phi)$$

Expert Systems

Ties together several streams of research –

Appraisal Theory and Practice

- *Shiller and Weiss (1999) – Type II errors*
- *Mass Appraisal*
- *Daubert & Kumho Tire*

Expert Systems

	Null hypothesis (H_0) is true	**Null hypothesis (H_0) is false**
Reject null hypothesis	Type I error False positive	Correct outcome True positive
Fail to reject null hypothesis	Correct outcome True negative	Type II error False negative

Expert Systems

	Null hypothesis (H_0) is true	Null hypothesis (H_0) is false
Reject null hypothesis	Type I error False positive	Correct outcome True positive
Fail to reject null hypothesis	Correct outcome True negative	Type II error False negative

Shiller & Weiss – Type II errors cause appraisal models to underestimate risk

Expert Systems

A brief sojourn into Daubert

Does the method center upon a testable hypothesis?
Is there a known or potentially knowable error rate associated with the method?
Has the method been subject to peer review?
Is the method generally accepted in the relevant scientific community?

Expert Systems

A brief sojourn into Daubert

Do(es) the method(s) center upon a testable hypothesis?
Is there a known or potentially knowable error rate associated with the method(s)?
Has the method been subject to peer review?
Is the method generally accepted in the relevant scientific community?

Expert Systems

Tie together several streams of research –

Set Theory

Fuzzy Logic

(as distinct from neural networks)

Expert Systems

Tie together several streams of research –

"…a 'fuzzy set'…extends the concept of membership in a set to situations in which there are many, possibly a continuum, of grades of membership."

-- Zadeh (1964)

Expert Systems

Tie together several streams of research –

"…a 'fuzzy set'…extends the concept of membership in a set to situations in which there are many, possibly a continuum, of grades of membership."

From a statistician's perspective, this sounds a whole lot like the way we determine "comparables"

-- Zadeh (1964)

Expert Systems

Tie together several streams of research –

Equilibrium Theory

What is the nature of the real estate market?

Nash (1951)

Expert Systems

Tie together several streams of research –

Equilibrium Theory

What is the nature of the real estate market?

Nash (1951)

Why does this matter?

Expert Systems

Tie together several streams of research –

Equilibrium Theory

What is the nature of the real estate market?

Nash (1951)

Why does this matter?

(hint: modeling heterogeneity)

Expert Systems

The real estate transactional market constitutes a Nash equilibrium, in which all participants take into account the strategies of other participants in the goal of optimizing their utility.

Expert Systems

The real estate transactional market constitutes a Nash equilibrium, in which all participants take into account the strategies of other participants in the goal of optimizing their utility.

Thus, spatial and temporal autocorrelation are part of the process, rather than aberrations to the model.

Expert Systems

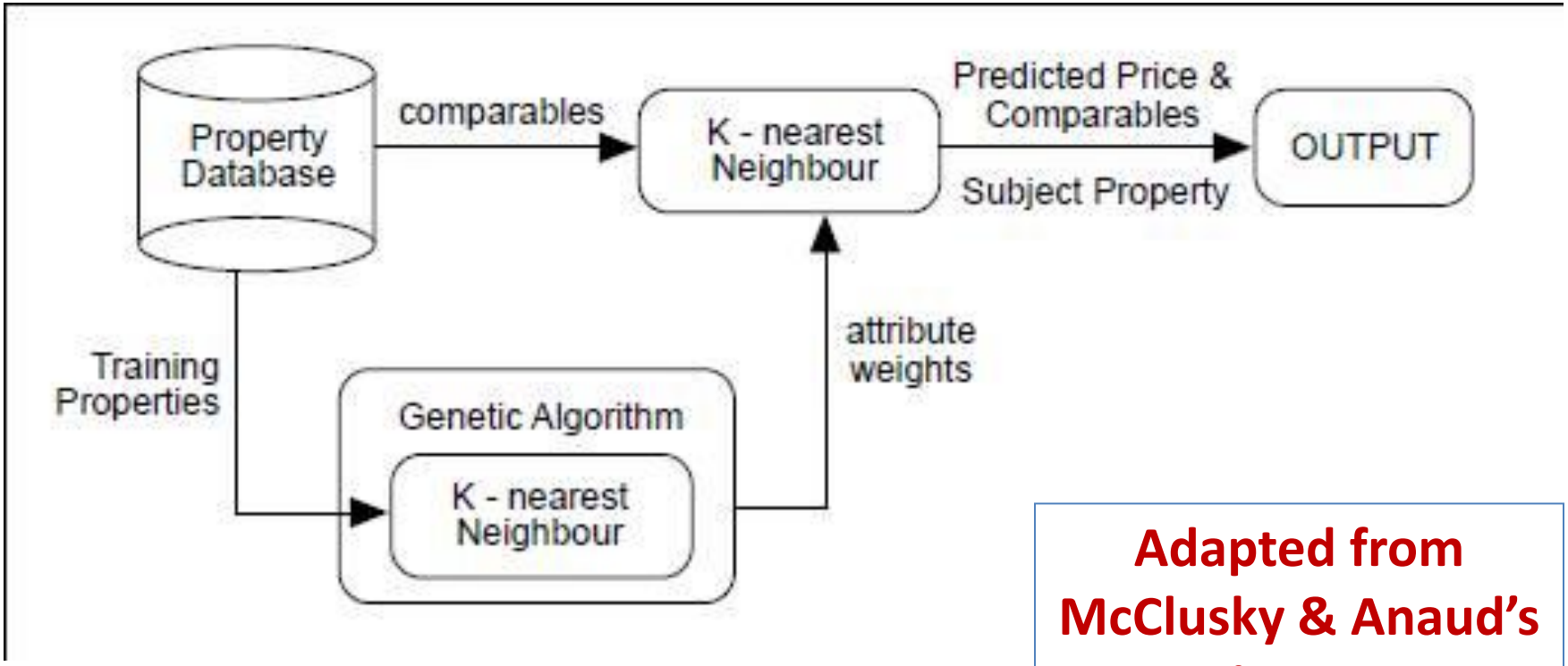
The appraiser, faced with a set of data and a set of prior observations about the underlying market, uses fuzzy logic to formulate a maximum likelihood estimator to determine the true value of the property.

Expert Systems

The appraiser, faced with a set of data and a set of prior observations about the underlying market, uses fuzzy logic to formulates a maximum likelihood estimator to determine the true value of the property.

S/he is able to do this with a limited data set based on the Bayesian priors already known about the probable behavior of the market.

Expert Systems



Adapted from McClusky & Anaud's Figure 4

Expert Systems

Two Case Studies:

- *Plaquemines Parish, LA*
- *Lomax, IL*

Expert Systems

Two Case Studies:

- *Plaquemines Parish, LA*
- *Lomax, IL*

$$COD = \frac{\sum abs(\text{Price} - \text{Value}) \Big/ n}{median\ value}$$

Expert Systems

$$COD = \frac{\sum abs(\text{Price} - \text{Value}) / n}{median\ value}$$

COD:
Coefficient of Dispersion
From the IAAO Supplemental Standards

Expert Systems

$$COD = \frac{\sum abs(\text{Price} - \text{Value}) \Big/ n}{median\ value}$$

COD:
Coefficient of Dispersion
From the IAAO Supplemental Standards

A measurement of the accuracy of the statistic

Expert Systems

Parametric Statistics – used when we expect that the underlying data is well distributed (i.e. – normal)

Non-Parametric Statistics – used when the data is not expected to be well defined or well distributed

Expert Systems

Parametric Statistics – used when we expect that the underlying data is well distributed (i.e. – normal)

Example – Mean, Standard Deviation

Non-Parametric Statistics – used when the data is not expected to be well defined or well distributed

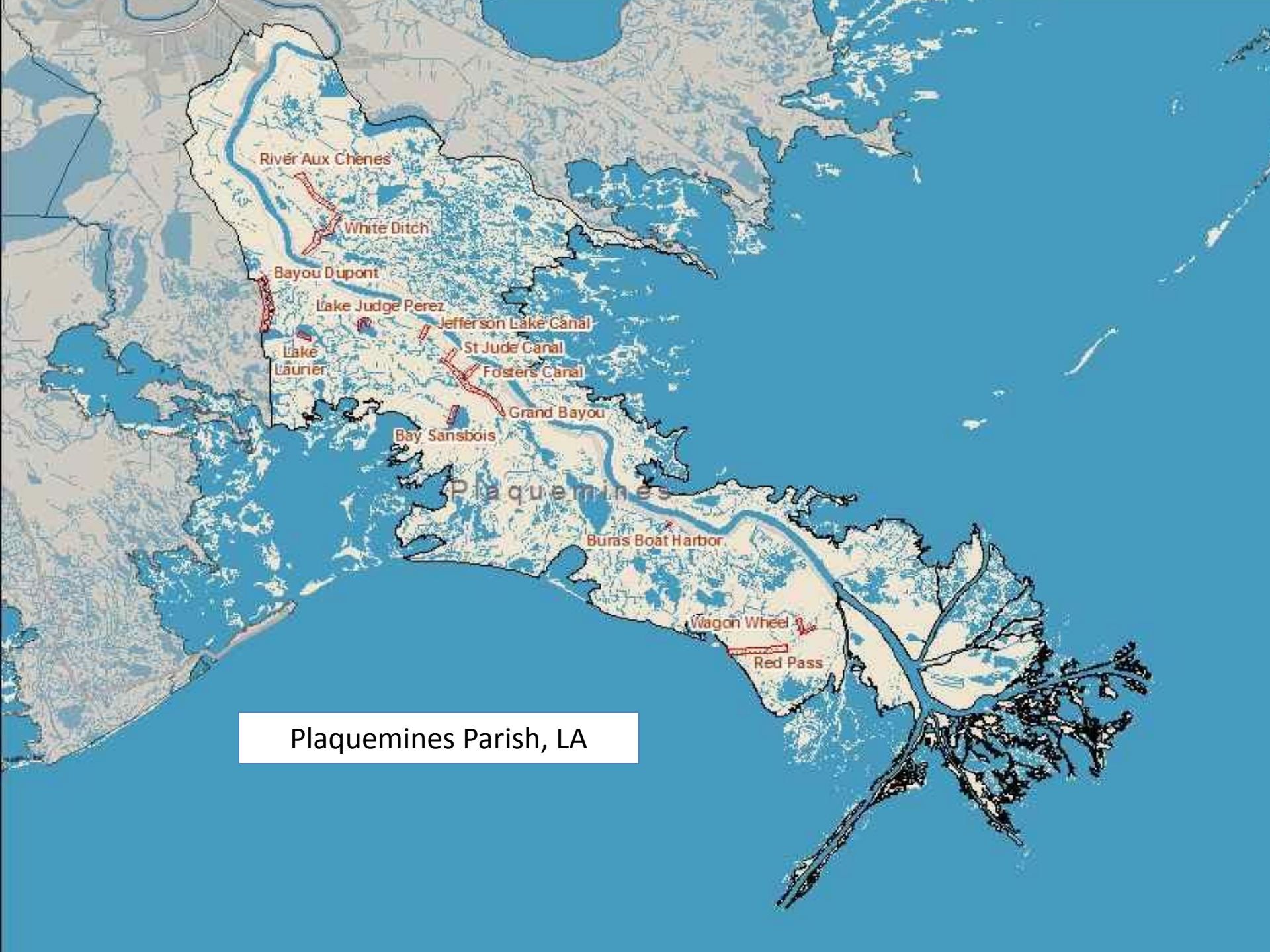
Example – Median, Coefficient of Dispersion

Expert Systems

Two Case Studies:

- *Plaquemines Parish, LA*
- *Lomax, IL*

$$COD = \frac{\sum abs(\text{Price} - \text{Value}) \Big/ n}{median\ value}$$



Plaquemines Parish, LA


Shortly after Katrina

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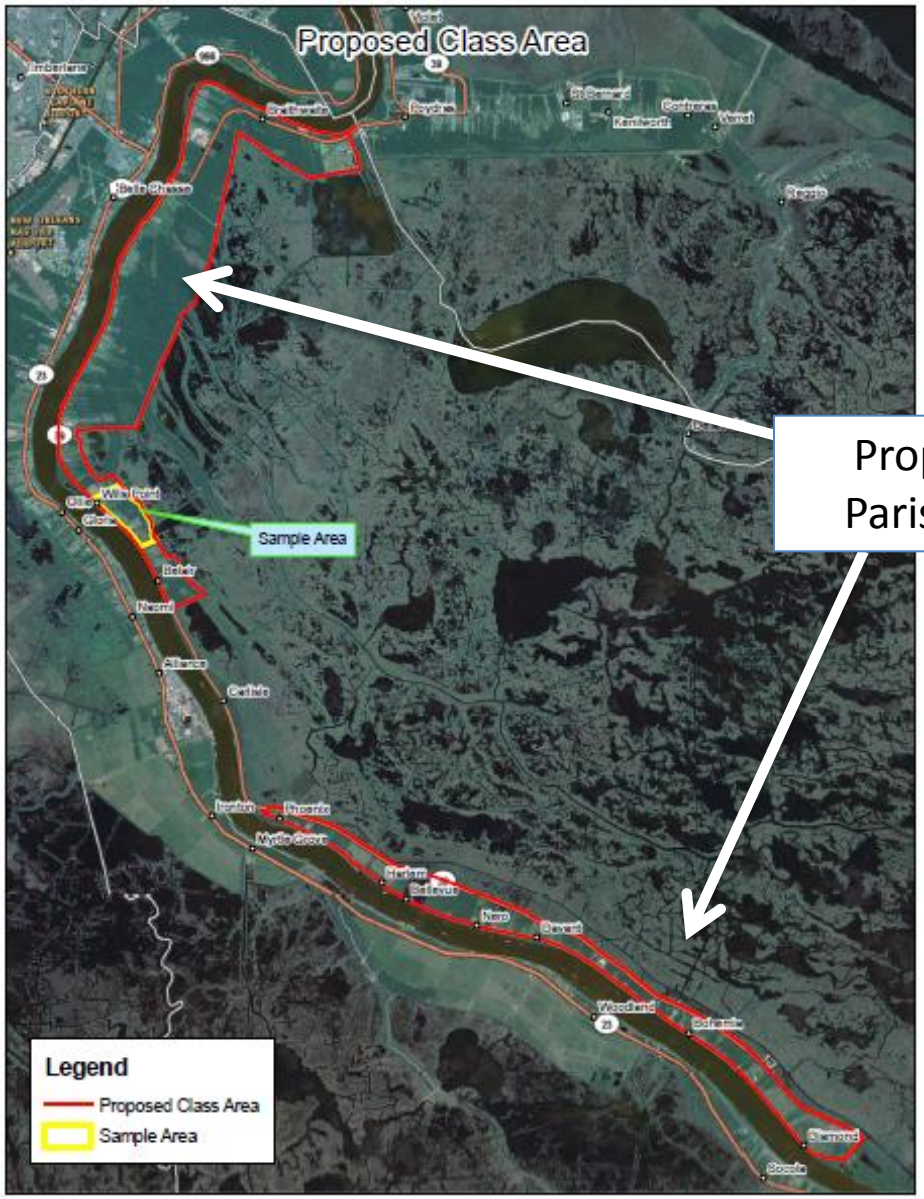

Proposed Plaquemines Parish Class Action Area

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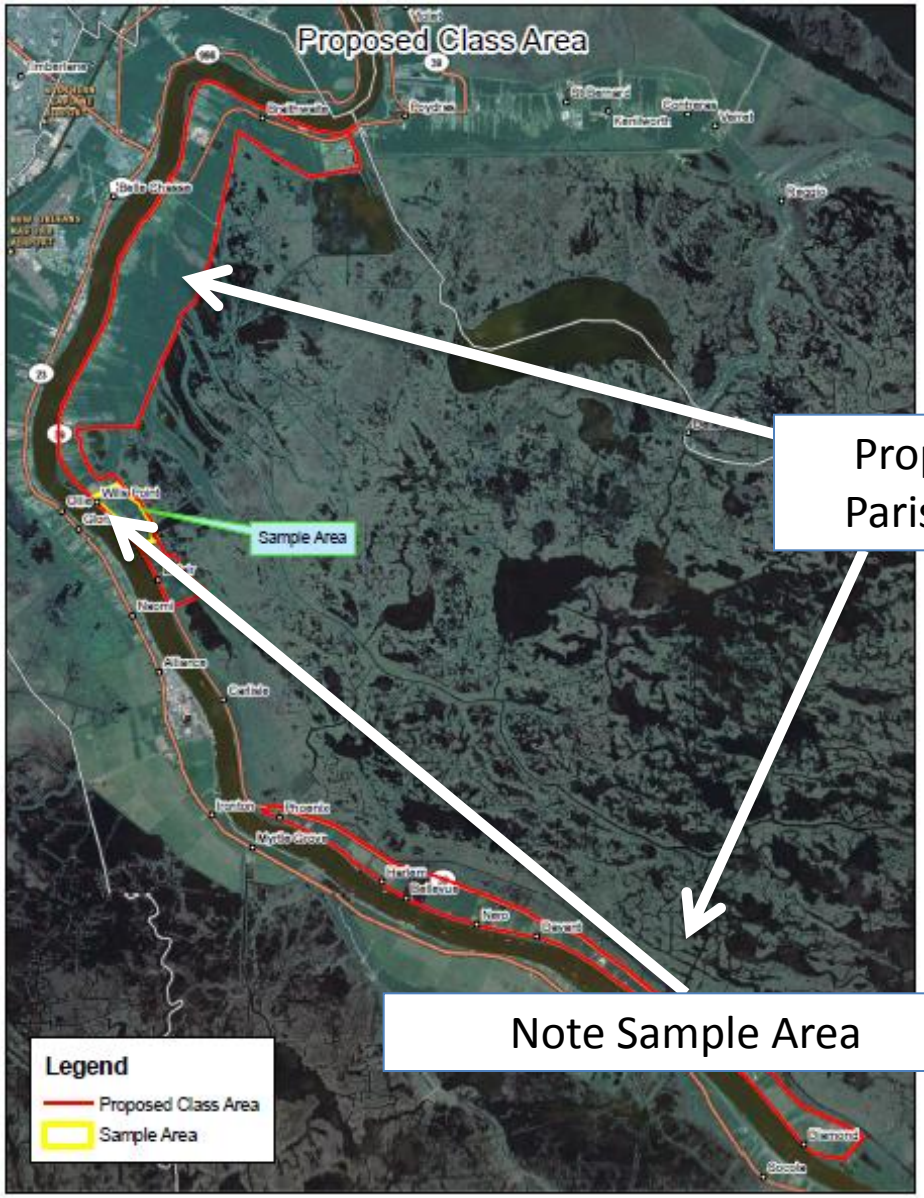

Proposed Plaquemines Parish Class Action Area

Note Sample Area

Table 1

Case Study No. 1 Valuation Example

Property Type	Base Value	Qual/Cond	Brick	Acres	SF	Distance
Coefficients →		$20,000	$5,000	$3,000	$25	-$500
Property type "J" base values	$48,000	2	0	0.5	1200	17
Property type "I" characteristics		2	1	0.3	1350	21

Val_i = $48,000
+ ((2-2)*$20,000) + ((1-0)*$5,000) + ((0.3-0.5)*$3,000) + ((1350-1200)*25) + ((21-17)*-500)

Val_i = $48,000 + $0 + $5,000 - $600 + $3,750 - $2,000

Val_i = $54,150

C.O.D. = 9.06%

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Proposed Lomax, Ill
Mass Tort Area

Table 4

Lomax Coefficients of Dispersion

Property Type	C.O.D
Double-Wide	8.05%
Mobile Home	35.21%
Old Style 1	21.81%
Old Style 2	13.40%
Ranch	7.67%

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Lessons Learned & Avenues for Future Research

The use of MLEs in an expert system

The use of non-parametric models to evaluate statistical properties ("known" error rates)

How is this applicable in a single-property appraisal model?

Kendall's tau (for collinearity & dependence)
-- also Spearman's ρ

Kolmogorov-Smirnov (for normality)

Mann-Whitney (to test if the difference in medians between two populations equals zero)
-- also X^2

Kruskal-Wallis statistic (variance)

Expert Systems – "must read"

Kilpatrick, "Expert Systems and Mass Appraisal", J. Property Investment and Finance, 2011

Lentz and Wang, J. Real Estate Research, 1998 – tells us that the sales adjustment grid is just a special case of the weighted least squares regression hedonic model.

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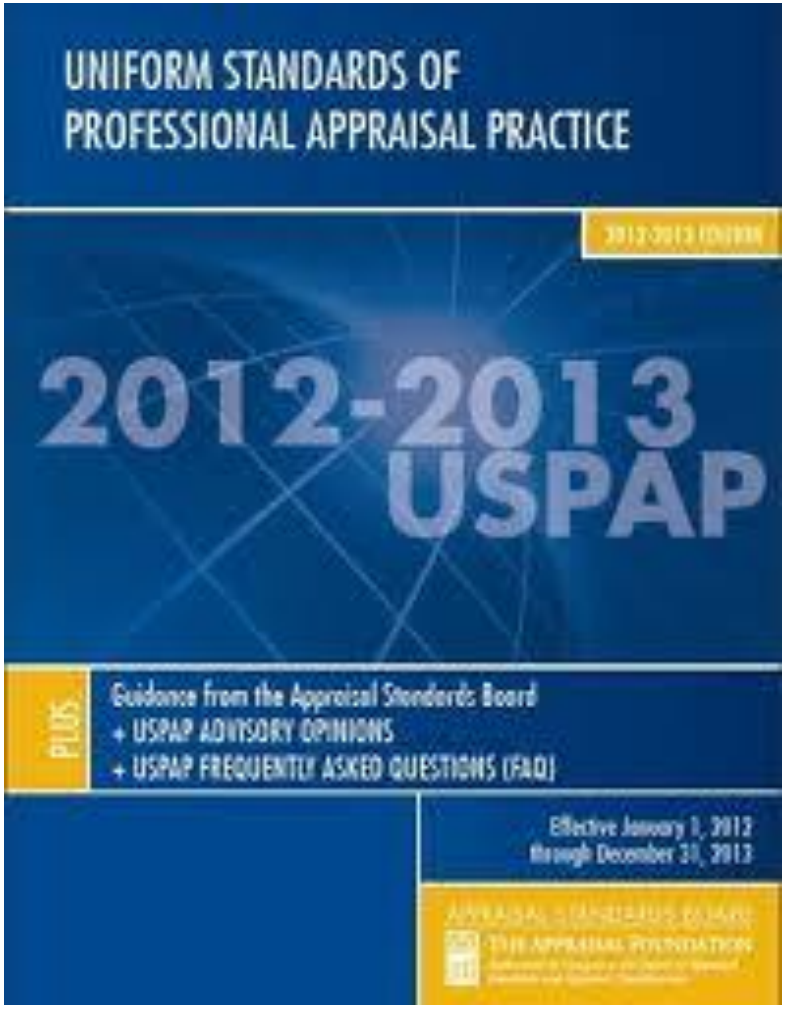

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Scope of Work Rule – current wording:

"The scope of work is acceptable when it meets or exceeds:

- *The expectations of parties who are regularly intended users for similar assignments; and*
- *What an appraiser's peers' actions would be in performing the same or a similar assignment"*

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Scope of Work Rule – Proposed 2014 update:

"The scope of work is acceptable when it meets or exceeds:

- *Both the expectations of parties who are regularly intended users for similar assignments and what an appraiser's peers' actions would be in performing the same or a similar assignment; or*

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Scope of Work Rule – Proposed 2014 update:

- *Recognized methods and techniques prescribed by the Appraisal Practices Board of the Appraisal Foundation, or in other peer-reviewed, published appraisal or valuation books and articles, and published appraisal or valuation coursework taught by a college, university, professional appraisal or valuation organization, or state and federal government agencies."*

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Standards Rule 1-1 (a)

"In developing a real property appraisal, an appraiser must… be aware of, understand, and correctly employ those recognized methods and techniques that are necessary to produce a credible appraisal."

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Standards Rule 2-2(a)(b)(c) (viii)

"(Describe) (Summarize) (State) the information analyzed, the appraisal methods and techniques employed, and the reasoning that supports the analyses, opinions, and conclusions…."

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Advisory Opinion 18

"An AVM's output is not, by itself, an appraisal, and communication of an AVM's output is not, in itself, an appraisal report."

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Advisory Opinion 18

"An AVM's output is not, by itself, an appraisal, and communication of an AVM's output is not, in itself, an appraisal report."

➔ *Both USPAP 1 and 6 may apply*

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Standards Rule 6-4(b) comment:

"Mass appraisers must develop mathematical models that, with reasonable accuracy, represent the relationship between property value and supply and demand factors, such as presented by quantitative and qualitative property characteristics."

USPAP?

Standards Rule 6-4(c) comment:

"Models must be calibrated using recognized techniques, including, but not limited to, multiple linear regression, nonlinear regression, and adaptive estimation."

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Comment to Standards Rule 3-1(a)

Changes and developments in economics, finance, law, and society can have a substantial impact on the appraisal profession. To keep abreast of these changes and developments, the appraisal profession is constantly reviewing and revising appraisal methods and techniques and devising new methods and techniques to meet new circumstances. Each appraiser must continuously improve his or her skills to remain proficient in appraisal review.

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Comment to Standards Rule 3-1(a)

The reviewer must have the knowledge and experience needed to identify and perform the scope of work necessary to produce credible appraisal assignment results. Aspects of competency for an appraisal review, depending on the review assignment's scope of work, may include, without limitation, familiarly with the specific type of property or asset, market, geographic area, analytical methods, and applicable laws, regulations, and guidelines.

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Code of Professional Ethics of the Appraisal Institute

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CPE?

E.R. 1-4

It is unethical in the performance of a service to knowingly fail to:

(a) Identify the appropriate Standards to be applied
(b) Disclose in any report the Standards applied
(c) Take all steps necessary or appropriate to understand the Standards applied

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Dr. John Kilpatrick, MAI, is an appraiser and financial economist and is the CEO of Greenfield Advisors, specializing in economic market and valuation analysis, principally in real estate matters, with offices in Seattle and Atlanta. He also serves as a *Visiting Scholar in Real Estate Finance* at Baruch College, City University of New York, and is a nationally certified USPAP instructor.

His Ph.D. is in Finance from the University of South Carolina, where he also taught Real Estate and Corporate Finance in the Moore School of Business. He also previously served as the founding Administrator of the South Carolina Supercomputer Network and as the Secretary/Treasurer of the Academic Coalition for Intelligent Manufacturing Systems, based in Washington, DC.

Dr. Kilpatrick is the author of four books, contributing author to three others, and has written over one hundred journal articles, book chapters, monographs, and other publications. He is a frequent speaker before national groups, such as the U.S. Senate Subcommittee on Science, Technology, and Space, the National Trust for Historic Preservation, the Asian Real Estate Society, and *Institutional Investor* magazine's Integrated Wealth Management Forum. His work in real estate finance has been the subject of recent articles in the New York Times, the Boston Globe, the Wall Street Journal, and the British magazine Modus. He is a contributing author to Brownfield Law and Practice as well as the American Bar Association's Brownfields 3rd Edition.

His recent consulting clients include the U.S. General Services Administration, the Hearst Family, the Japan Real Estate Institute, and numerous private investors, corporations, university endowments, trusts, and law firms. Among his other honors, Dr. Kilpatrick is a *Fellow* of the Faculty of Valuation of the British Royal Institution of Chartered Surveyors, a *Fellow* of the American Real Estate Society, and is featured in Who's Who in America.