The Impacts of Oil and Gas Pipelines on Urban Residential Property Values: A Case Study in Houston

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Outline

- This presentation is organized in five parts.
  1. Introduction
  2. Reviews the relevant literature.
  3. Describes the methodology and analysis procedures.
  4. Applies the model to an empirical study.
  5. Discusses the findings and draws conclusions.

Introduction

- As the most common mode of transportation for oil and gas, pipeline has become a necessary need for urban economic development.
- Many pipelines are aging because they were installed as far back as the 1920's and poses significant risk of failure if preventative and mitigative measures are ignored or not timely addressed.
- Congress, state and local government agencies and the pipeline industry are taking a proactive approach to ultimately prevent or minimize risks and losses from potential pipeline incidents (2002 Pipeline Safety Improvement Act).
- A recent report from Transportation Research Board report (TRB, 2004) states that residential development in corridors of oil and natural gas pipelines have contributed to an increasing number of pipeline “incidents” involving fatalities, injuries or significant property damages.
- Recent incidents of oil and gas pipelines in urban areas have brought attention to urban residents and planners of the potential risks from having pipeline facilities in residential neighborhoods.

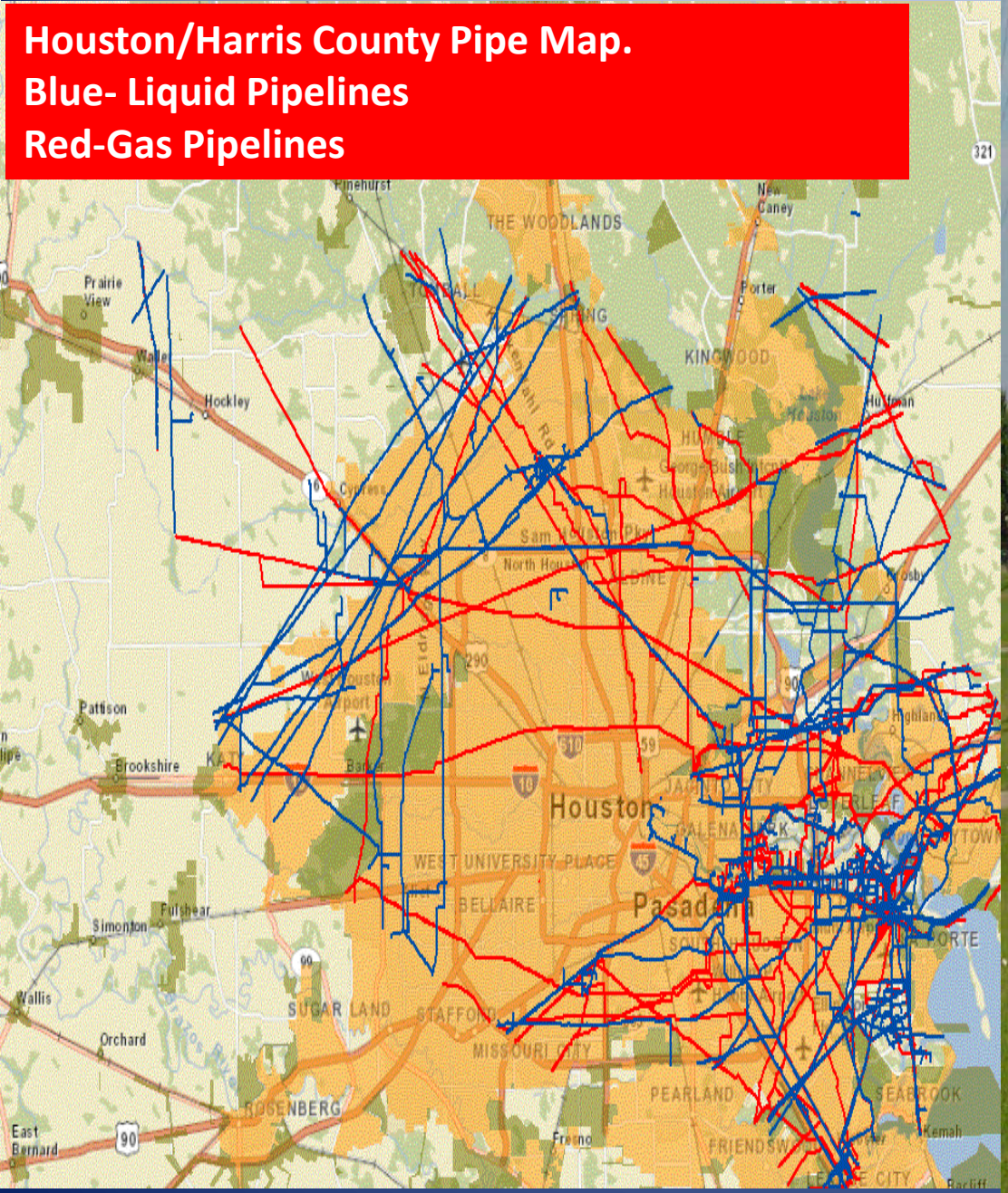
Source: L A Times (2010)

Source: TRRC Investigator R.Daniel

Source: TRRC Investigator R. Daniel

Source: TRRC Investigator R. Daniel

Houston/Harris County Pipe Map.
Blue- Liquid Pipelines
Red-Gas Pipelines



Source: TRRC Investigator R. Daniel

Data Source: National Piping Mapping System (NPMS)

Intro con't

- Urban resident concerns have increased due to the potential risk underground oil and gas pipeline poses to their health and property
- Property owners usually claim that future buyers intend to pay less for properties right on or close to oil and gas pipelines
- Those claims root from the fear of hazards to human health and safety associated with living near pipeline ROWs.
- The density of pipelines differs from neighborhood and the distance from pipelines varies from property.
- Therefore, it may become necessary for both planners and residents to know how significant pipeline proximity, if any, affect residential property values.
- This paper examines the impact of oil and gas pipelines on residential property values in Houston, Texas

Intro Cont.

- The study obtains data from a variety of sources:
  - 2010 InfoUSA household data
  - Texas Railroad Commission (TRRC) pipeline data from local oil and gas pipeline companies
  - Census CTPP 2000

- It utilizes three groups of variables:
  1. physical,
  2. neighborhood, and
  3. accessibility characteristics of properties

Literature Review

- The literature on hazardous facilities effects on residential property values can be categorized into two groups:
  - One group of research concentrates on the effects of proximity to hazardous or undesirable facilities, including oil and gas pipelines
  - Second group focuses on evaluating the impacts of hazards, such as oil and gas pipeline release

- Because this study focuses on the effects of oil and gas pipelines on residential property values, it summarizes the literature within the first group.

- Some relevant studies analyzing the effects of high voltage transmission lines (HVTL) on residential property values are also considered.

Literature Review Con't

- Kinnard and Dickey (1995) utilized multiple regression studies on the effect of HVTL and found the following:
  - a substantial negative effect on property values
  - but at the same time, the multiple regression analysis study found the observed price, marketing time, and sales volume effects tends to be statistically insignificant.

- Colwell (1990) also employed multiple regression models to examine the effects of HVTL and towers on the selling price of nearby residential property. Similar to other studies he found:
  - the negative impact of power lines large in close proximity to PL but decreases as distance increases
  - the impacts of the power lines lessens with time.

Literature Review Con't

- Pipelines may have similar effects as HVTL on the selling prices of residential properties but, buyers attitude may be viewed differently:
  - pipelines are usually buried under ground
  - HVTL is visible above ground

- Simons (1999) found that single family dwelling and townhome sales experienced a significant reduction in sales price within a two mile radius north of the 1993 pipeline rupture in North Fairfax County.
  - But also found a large group of property along the pipeline ROW having insignificant reduction on property values.

- Diskin et al. (2011) employed matched-pairs analysis to examine data from approximately 1,000 parcels in a subdivisions within a 14 and 19 mile radius Northwest and Southeast Downtown Phoenix and found the following:
  - inconclusive relationship between proximity to pipeline and sales prices of residential properties
  - 11-21% deduction of values for residential property near the pipeline
  - also found higher percentages of premium property near pipeline ROW
  - findings are consistent to prior studies
  - recommends continued examination of the issue using samples from different geographic areas.

Methodology

- Because the effects of proximity to pipeline on residential property values are inconclusive, this study:
  - intends to fill the gap
  - contributes to the literature by extending the study to an empirical case in Houston, Texas, the hub of oil and gas pipelines.
  - Similar to relevant studies, employs hedonic price modeling
  - employ a more sophisticated approach
    - modeling the relationship between sales prices of residential properties and proximity to pipeline as well as a large number of explanatory variables.

- Use both the Ordinary Least Square (OLS) model and the Multi-level Regression Model (MLR) to examine the effects of oil and gas pipelines (OGP) on residential property values.
  - A general hedonic regression model for analyzing the issue is shown as follows:

$$Y = a_0 + \sum_{i=1}^{I} b_{1i} H_i + \sum_{j=1}^{J} b_{2j} N_j + \sum_{k=1}^{K} b_{3k} A_k + \varepsilon$$

- where,

  Y= the dependent variable, i.e. the value of an individual property

  H_i = refers to physical characteristics variables of the property such as:
    - home size
    - home age
    - number of bath rooms, etc.

  N_j = the variables of neighborhood characteristics where the property is located such as:
    - population density,
    - job density
    - median income, etc.

  A_k = the accessibility and location variables such as:
    - proximity to pipeline,
    - distance to job centers,
    - and job accessibility, etc.

  ε = the residual

  a and b = parameters.

Methodology Con't

- The first stage hedonic analysis employing the OLS model:
  - examines fixed effects (home size, home age etc.)
  - ignore spatial difference in property-related variables
    - Density of PL, number of PL, Pop density, etc.

- A second-stage estimation is suggested which will employ those available aggregated zonal attributes (from census tract, TAZ etc.)

Methodology Con't

- Multilevel regression models are thought to handle property related data more adequately because It separates hierarchical data at two levels (Pan 2012):
  - the individual property level
  - the aggregated traffic analysis zone (TAZ) level

- Pan (2012) employed a two-level regression model with multiple variables to examine the impacts of an urban light rail system on residential property value

- A similar two-level model can be employed to analyze the effects of pipelines on residential property values. The model is shown as follows,

Methodology Con't

Level-one model: $$Y_{ij} = \beta_{0j} + \sum_{p=1}^{P} \beta_{pj} x_{pij} + e_{ij}$$

Level-two model: $$\beta_{pj} = \gamma_{p0} + \sum_{q=1}^{Q} \gamma_{pq} z_{qj} + u_{pj}$$

- where,

  Y is the dependent variable,

  x is a level-one explanatory variable,

  z is a level-two explanatory variable,

  β is a group dependent coefficient,

  Y is a coefficient,

  e is the level-one residual,

  u is the level-two residual.

Methodology Con't

- The full model is a combination of level-one and level-two models as follows

$$Y_{ij} = \gamma_{00} + \sum_{p=1}^{P} \gamma_{p0} x_{pij} + \sum_{q=1}^{Q} \gamma_{0q} z_{qj} + \sum_{p=1}^{P} \sum_{q=1}^{Q} \gamma_{pq} z_{qj} x_{pij} + u_{0j} + \sum_{p=1}^{P} u_{pj} x_{pij} + e_{ij}$$

- The model includes a number of explanatory factors at two spatial levels,
  - the individual property level
  - the aggregated zonal level

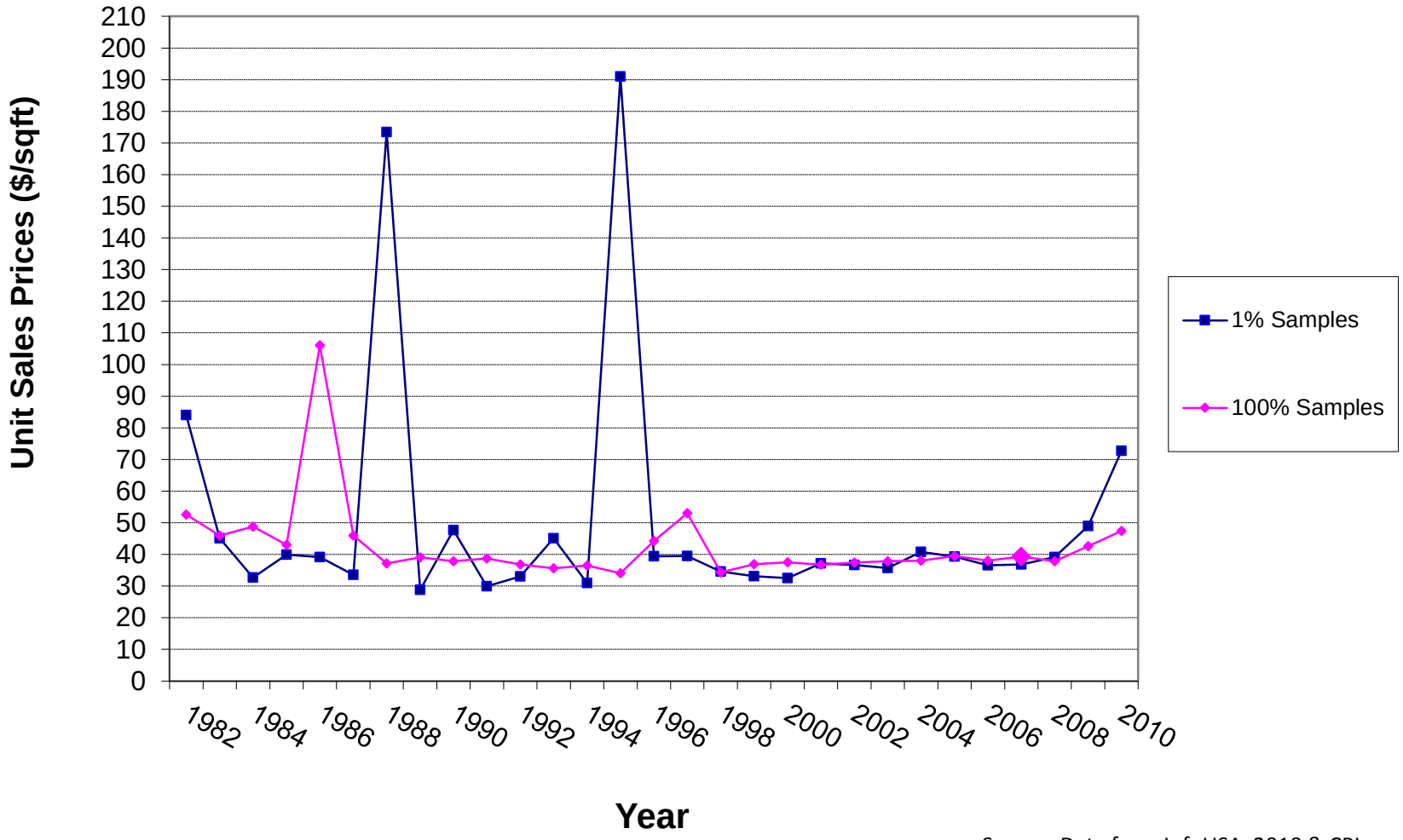
Methodology Con't

- Pipeline related explanatory variables are also separated by two spatial levels.
  - The variables at individual property level include
    - proximity to the nearest pipelines
    - type of commodities transported by the nearest pipeline.
  - The factors at zonal level include
    - pipeline density
    - number of pipelines.

Data Source

- InfoUSA's 2010 databases is employed for residential households and extract:
  - values of home sales price, transaction date of home sale, home size, and home age, etc.
- Converted home sales prices at different years to comparable values using the Consumer Price Index (CPI) from the Bureau of Labor Statistics (BLS).
- To test the computational efficiency and examine the spatial regression performance,
  - this study selects 1 percent random samples from the total observations.

Figure 1. Unit Home Sales Prices in the region for 1 Percent and 100 Percent samples, 1983-2010



Source: Data from InfoUSA 2010 & CPI

Data Source con't

- Census CTPP 2000
  - Provided average travel time by origin-destination (OD) pairs
  - Offers GIS maps of the TAZs, which are utilized to facilitate the calculation of
    - job accessibility,
    - identification of employment centers, and
    - examination of spatial relationship between objects, etc.
  - Population data, income, and race used to calculate
    - population density,
    - median income, and
    - percent of minority by TAZ.

- This study also acquires GIS data in Harris County from local planning agencies for:
  - highway alignments, bus stops, light rail stations

- Texas pipeline data from the Texas Railroad Commission (RRC) includes:
  - the location and alignment of the pipelines,
  - the operator's names, the commodities transported,
  - the diameter of the pipeline, the types, status, and descriptions of the pipeline systems, etc.

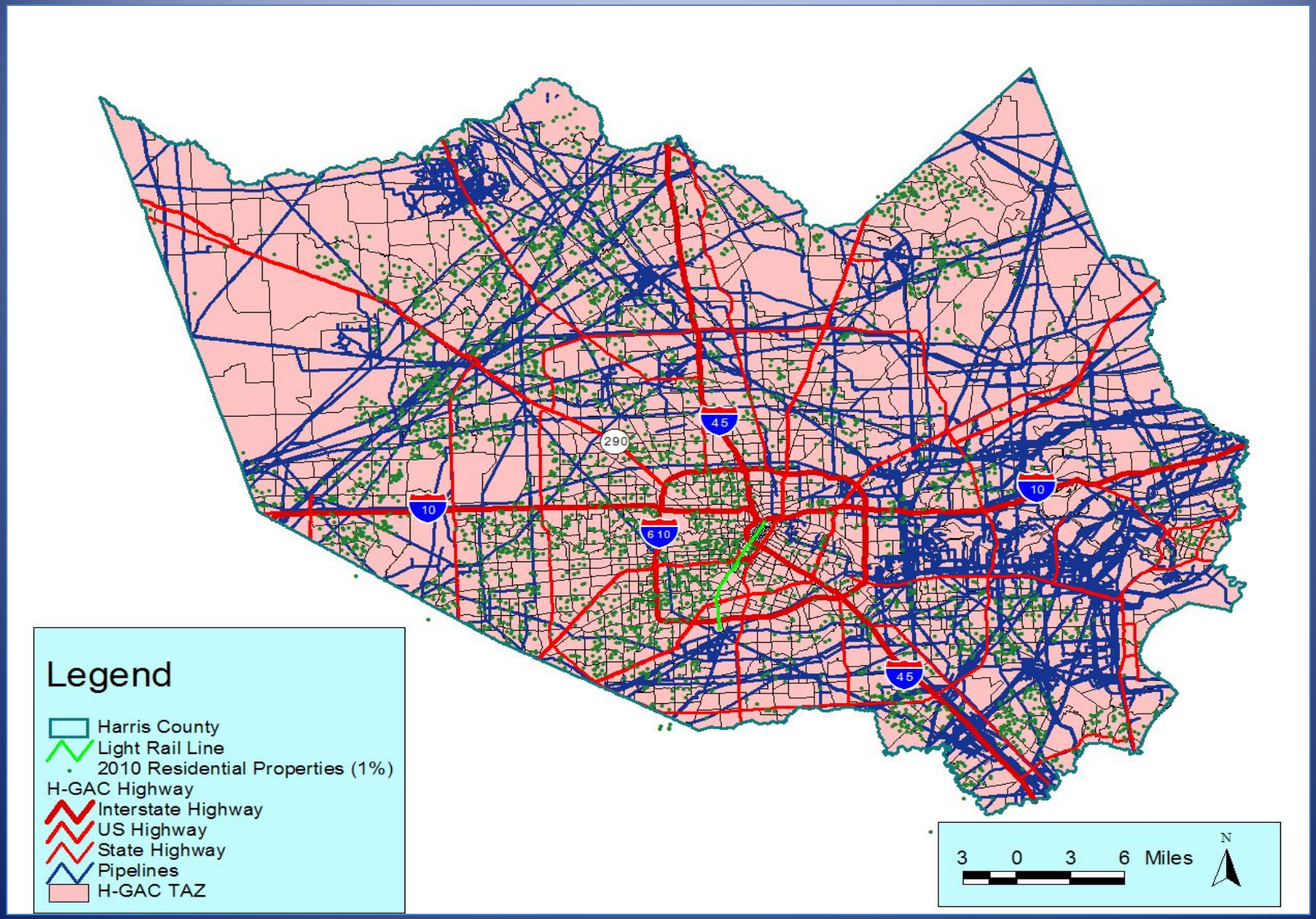


Fig 2 Pipelines and Residential properties in Harris County, 2010. Source: GIS Data

Data

- Using the spatial analysis functions of GIS, this study estimates for each residential property :
  - the distance to the nearest pipeline,
  - the type of commodity transported by the nearest pipeline,
  - the number of pipelines and the percentage of areas covered by pipelines in the TAZ where the property is located.

- The dependent variable is the logarithm of home sale prices obtained from the InfoUSA's 2010 household data set and adjusted using the 1983 Consumer Price Index (CPI).

- All the explanatory variables are separated into two spatial levels for the MLR model:
  - The first level variable or individual property level include home physical attributes, such as:
    - home size and home age, proximity to nearest PL , type of commodity transported, a dummy variable for home sale before or after the opening of the light rail line

  - The second-level explanatory variables are neighborhood characteristics and accessibilities at an aggregated zonal level, including :
    - population density, total job density, pipe density, number of PL, etc.

Table 1. Home sales prices, home size, and home age at different distances to pipelines

Distance to Pipelines	Number of Properties	Unit Home Sales Prices ($/sqft)	Home Size (sqft)	Home Age
Less than1/4 Mile	139,622	34.23	2,506	26
1/4-1/2 mile	79,222	34.56	2,532	28
1/2 to 1 mile	66,144	38.95	2,622	30
1-2 mile	35,295	52.23	2,780	37
2-3 mile	14,687	58.73	3,056	36
Within 3 miles	334,970	38.55	2,588	29
Beyond 3 miles	3,155	70.20	2,530	29
Regional Average	338,125	38.84	2,588	29

Source: Author Calculation using InfoUSA's 2010 household database.

Table 2. Types of Commodities Transported by Pipelines, Harris County

CommID	COMMODITY	Number of Properties Nearby
1	Anhydrous Ammonia	0
2	Carbon Dioxide	0
3	Crude Oil	97,651
4	Empty	2,529
5	Highly Volatile Liquid	16,439
6	Hydrogen Gas	1,025
7	Liquid Petroleum Gas	2,527
8	Natural Gas	171,513
9	Natural Gas Liquids	17,124
10	Product	29,317

Source: Author summarization from the pipeline data

Analysis and Results

- This study examines the effects of oil and gas pipelines (OGPs) by developing four models with multiple sets of variables
  - (test spatial structure of data)

- Model l is the base model with no explanatory variables, which is used to assist with the calculation of a pseudo R-squared value for the following models.

- Model 2 tests the explanatory power of the physical characteristics of residential properties, including home size and home age.

Analysis Con't

- Model 3 consists of all the variables at the first level, i.e. the individual property level.
  - it adds the distances to the CBD and the Texas Medical Center as two explanatory variables.
  - has a number of transportation access variables, including :
    - a dummy variable for home sale before or after rail line opened,
    - access to bus stops,
    - distance to light rail stations, and
    - distance to highways.

- As for the pipeline variables,
  - Model 3 adds distance to the nearest pipeline
  - a number of dummy variables representing the type of commodities transported by the nearby pipelines including
    - crude oil,
    - empty pipeline,
    - highly volatile liquid (HVL),
    - hydrogen gas,
    - liquid petroleum gas, natural gas, natural gas liquids, etc.

Analysis Con't

- Model 4 add all the explanatory variables at level 2, the zonal level, including
  - population density,
  - job density,
  - median income,
  - job accessibility,
  - percentage of minority population,
  - number of pipelines, and
  - density of pipelines calculated as the ratio of the area occupied by pipelines.

Table 4. Results from Model 1, 2, and 3

	Model 1		Model 2		Model 3	
	MLR	OLS	MLR	OLS	MLR	OLS
Fixed eff.						
Level 1						
Intercept	4.0728 ***	4.2676 ***	3.8972 ***	3.4106 ***	4.1467 ***	3.7636 ***
Homesize			0.0002 ***	0.0004 ***	0.0002 ***	0.0003 ***
Homeage			-0.0092 ***	-0.0041 ***	-0.0093 ***	-0.0091 ***
D2railst					0.0169 ***	0.0155 ***
Dist2hwy					-0.0008	0.0023 ***
Railop					0.0218 ***	0.0139 ***
Busstqmi					-0.0187 ***	0.0478 ***
Dist2dt					-0.0038 ***	-0.0067 ***
Dist2mc					-0.0152 ***	-0.0114 ***
Dist2pipe					0.0097 ***	0.0383 ***
CrudeOil					0.0003	0.1304 ***
Empty					0.0125	0.0537 ***
HVL					-0.0253 ***	-0.0870 ***
Hydrogas					-0.0122	-0.1018 ***
LiqPetro					-0.0023	-0.0595 ***
Natgas					-0.0062	0.0146 ***
Natgasliq					-0.0047	0.0100 ***
Random eff.						
Level 1						
Intercept	0.4003 ***		0.3376 ***		0.3376 ***	
Level 2						
Intercept	0.3618 ***		0.1725 ***		0.1241 ***	
R_SQ[a)]				0.3274		0.396
Pseudo R_SQ[b)]			0.3307		0.3942	
Obs. of Level 1	338125		338125		338125	
Obs. of Level 2	1414		1414		1414	

Table 5. Results from Model 4 of MLR and OLS.

	Model 4 - MLR			Model 4 - OLS		
	Coeff.		S.E.	Coeff.		S.E.
Fixed eff.						
Level 1						
Intercept	3.1396	***	0.1547	3.7786	***	0.0230
Homesize	0.0002	***	0.0000	0.0003	***	0.0000
Homeage	-0.0093	***	0.0001	-0.0097	***	0.0001
D2railst	0.0088	***	0.0014	0.0054	***	0.0003
Dist2hwy	-0.0012		0.0005	-0.0004	***	0.0002
Railop	0.0221	***	0.0022	0.0227	***	0.0023
Busstqmi	-0.0155	***	0.0040	0.0709	***	0.0033
Dist2dt	-0.0034	***	0.0010	-0.0036	***	0.0002
Dist2mc	-0.0094	***	0.0009	-0.0068	***	0.0002
Dist2pipe	0.0100	***	0.0009	0.0234	***	0.0004
CrudeOil	-0.0005		0.0057	0.0682	***	0.0043
Empty	0.0148		0.0157	0.0962	***	0.0127
HVL	-0.0224	***	0.0083	-0.0447	***	0.0061
Hydrogas	-0.0076		0.0224	-0.1073	***	0.0193
LiqPetro	0.0004		0.0146	0.0033		0.0126
Natgas	-0.0060		0.0054	0.0234	***	0.0039
Natgasliq	-0.0070		0.0083	-0.0023		0.0061
Level 2						
Popdens	0.0017		0.0018	-0.0076	***	0.0004
Jobdens	0.0032	***	0.0004	0.0026	***	0.0002
MedInc	0.0057	***	0.0003	0.0031	***	0.0000
Access	0.5157	***	0.0712	0.2113	***	0.0102
Pctminor	-0.4939	***	0.0331	-0.5875	***	0.0065
Pipenum	0.0004		0.0005	0.0016	***	0.0001
Pipearatio	-38.7840	***	6.6251	-27.2331	***	1.2481
Random eff.						
Level 1						
Intercept	0.3377	***	0.0008			
Level 2						
Intercept	0.0569	***	0.0024			
-2RLL	596786.8					
AIC	596790.8					
R_SQ[a)]	0.4371			0.4371		
Pseudo R_SQ[b)]	0.4822					
Obs. of Level 1	338125			338125		
Obs. of Level 2	1414					

Conclusion

- This study indicates that MLR models have advantages in dealing with spatial data with hierarchical structure (2-level separation).
- Consistent with the empirical studies in the literature, this study also finds that:
  - the physical characteristics of properties, home size and home age, are the dominant contributors to home sales prices (all Models).
- Both MLR and OLS models consistently report that the density of pipelines and proximity to pipelines have significant negative impacts on property values in residential neighborhoods.
- Residential property value decreases with close proximity to PL (Table 1)
- The models also show that different commodities transported by pipelines have different effects on residential property values but MLR model and OLS model do not report the same effects.
- Although more properties are in close proximity to Natural Gas PL (Table 2), HVL significantly affect property value negatively by both MLR and OLS models.
- Comparing the results of MLR & OLS from the different model runs, this study finds that:
  - all the significant variables have close coefficients and hold exactly the same signs (- or +) which provides reasonable expectations and certain confidence for the effects of these variables.