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DO GASOLINE PRICES AFFECT RESIDENTIAL PROPERTY VALUES?

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EXECUTIVE SUMMARY

This paper estimates the effect of gasoline prices on home values and explores the degree to which the relationship varies across a city. Using data from 930,702 home sales in Clark County, Nevada, from 1976 through 2010, we find that gasoline prices have significantly different effects on the sales price of homes in different neighborhoods. A ten percent increase in gasoline prices is associated with changes in location-specific average home values that span a range of over $13,000. This suggests that energy policies may affect household housing wealth via gasoline prices, a heretofore unrecognized distributional outcome.

I. INTRODUCTION

A large literature explores the economic and distributional effects of potential carbon pricing policies, including how taxing carbon could raise retail energy prices and differentially affect households across regions and income classes.[1] A growing literature connects the effects of energy prices to the value of durable household goods.[2] For example, Busse et al (2013) estimate consumers' willingness to pay for vehicle fuel economy and find that a $1 increase in the price of gasoline is associated with an increase of $354 in the average price of the highest fuel economy quartile of cars relative to that of the lowest fuel economy quartile. They found an estimated relative price difference of $1,945 for used cars.

Hedonic studies of home values have analyzed how home heating oil prices and energy efficiency investments could be capitalized into home values,[3] but so far

[1] EPA (2010), Hassett et al (2009), Rausch et al (2010), Mathur and Morris (2014).

[2] Langer and Miller (2013)

[3] Walls et al (2013) review this literature and find that households do value the energy-related costs of home ownership as reflected in the price premium associated with energy efficiency

no research has examined the potential of fuel taxes to affect home prices, and little research has related gasoline prices to households' willingness to pay for homes.[4] Households adjust to changes in gasoline prices via their choices of vehicle, where to live and work, and mode of transport. Communities adjust through investments in infrastructure and housing supply. Inducing these shifts is key to reducing greenhouse gas emissions from transport fuels. Thus, understanding how housing markets respond to gasoline prices is important for anticipating the environmental and distributional outcomes of energy policies.

The relationship between gasoline and housing markets could also be important to understanding broader housing market dynamics, including the relative prices of close-in and far flung homes, mortgage performance, the 2008 housing bust, and the location of new housing supply. For example, Glaeser et al (2012) find that during the last two housing booms, home prices rose significantly less in areas farther from the central business district. Gasoline prices could help explain why their result was far more pronounced during the 1996-2006 housing boom (a period in which real gasoline prices tripled) than during 1982-89 housing boom (a period in which real gasoline prices fell) and why, during the second boom, the price growth gradient was flatter in areas in which more adults take public transit.

Some evidence links gasoline prices to lending risks and the 2008 housing bust. For example, Kaufmann et al (2011) show that spikes in gasoline prices can stress household budgets and contribute to mortgage non-performance. Cortright (2008) relates the initial signs of the collapse of the housing bubble with the run-up in oil prices in 2008. And Sexton et al (2012) connect the rapid run-up of gasoline prices in 2007 to 2008 to the bursting of the U.S. housing market bubble. Their simulations support their theory that the greater the commuting distance from the central business district, the more a gasoline price shock causes home values to decline.

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certification. Eicholtz et al (2013) find that certified green buildings have rents and asset prices that are significantly higher than those documented for conventional office space.

[4] Coulson and Engle (1987) find that increases in gas prices between 1974 and 1979 boosted the differential between central city and suburban house prices in a sample of six cities.

Molloy and Shan (2013) investigate the effect of gasoline prices on the location of new home construction and home prices across the United States. They find that a 10 percent increase in gasoline prices leads to a 10 percent decrease in construction in locations with a long average commute (greater than 24 minutes) relative other locations, but they find no significant change on house prices. However, they find that in areas where the housing supply is constrained by regulatory or geographic factors and demand for housing is growing, gasoline prices have a significant negative effect on home prices in areas with long commutes. Their results suggest that if gasoline prices fall and demand for homes in the suburbs grows, developers usually just build more suburban homes. If they can't for some reason, then the value of those suburban homes goes up, and the lower gasoline prices can boost suburban home values.

The paper extends the literature in several ways. It is the first to look for direct evidence of gasoline prices on property values using property-level data and the first to directly estimate price-price elasticities of the two goods or to characterize the question in that way. This paper is also the first to produce graduated color maps that show spatial variations in the gasoline price effects, their statistical significance, and the estimated mean effects on home values. We find that the elasticities are statistically significantly different from each other in most of the more than 50,000 location-location pairwise F-tests, and we graph the results in a way that is common in science but new to the economics literature.[5] Finally, we directly apply our results to the potential outcomes of climate and energy policies.

Our approach is different than that of Molloy and Shan (2013) in that our data is more spatially detailed and allows estimation of within-city differences in gasoline price effects with no *a priori* assumptions about which neighborhoods are likely to be most sensitive to gasoline prices (such as those with long commutes). This allows us to pick up relationships that could depend on factors other than work-related travel.

As noted by Malloy and Shan (2013), significant capitalization of gasoline prices may be more likely in areas where short run housing supply is inelastic, such as

[5] Padmos et al (2008), Table 1; Araya et al (2014), Extended Data Figure 10: Full-resolution view of global pairwise transcription factor co-association matrix.

Las Vegas. According to Saiz (2010), about 32 percent of the Las Vegas metropolitan area is undevelopable owing to physical or regulatory constraints, making it the 32nd most-constrained housing supply in the United States of the 95 metropolitan statistical areas that have a population over 500,000. In addition, the U.S. federal government controls about 90 percent (about 4.66 million acres) of the land in Clark County.[6] Several land sales by the U.S. Bureau of Land Management expanded the land available for housing development during the period of our data, but the large share of government ownership and the mountainous terrain surrounding the Las Vegas valley may, at least at times and in some places, impede the response of private markets to increased housing demand.[7] According to Saiz (2010), Las Vegas is less constrained than a number of other large metropolitan areas such as New York City, Chicago, San Francisco, Los Angeles, San Diego, Miami, and Boston. Thus our results could suggest a role for gasoline prices in home values in other major property markets.

This paper proceeds as follows. Section 2 describes the hedonic model. Section 3 describes the data for property sales and gasoline prices. It also addresses potential problems of misspecification. Section 4 reviews the results, and Section 5 concludes. The appendix describes the treatment of the data in more detail and presents the results of an alternative (repeat sales) model.

2. METHODOLOGY

Hedonic regression is a standard approach for estimating the relationship between the prices of houses and their characteristics.[8] Owing to its intrinsically reduced form nature, no particular theory governs the structure or functional form of hedonic price models. A hedonic price schedule is simply the locus of tangencies between consumers' bid functions and suppliers' offer functions.[9]

Our standard hedonic property price model postulates that the inflation-adjusted selling price of a house is a function of its physical characteristics and other

[6] Clark County Department of Comprehensive Planning (2013).

[7] The Southern Nevada Public Land Management Act of 1998 allows the Bureau of Land Management to sell public land within a specific boundary around Las Vegas.

[8] Rosen (1974), Campbell et al (2011)

[9] Chay and Greenstone (2005)

factors. The data include 930,702 home sales in Clark County, Nevada, from 1976 through 2010. Clark County has a population of over two million residents and includes the two largest cities in Nevada, Las Vegas and Henderson. Its sprawling metropolitan area epitomizes large automobile-dependent western-U.S. cities.

The typical log-log hedonic estimation equation for y_{ist}, the log price of house *i* in census tract *s* in the period of sale *t*, is:

$$1) \qquad y_{ist} = c + \alpha_s + \gamma_t + \beta' X_i + \lambda_s g_m \alpha_s + \mu_s u_m \alpha_s + \epsilon_{ist}.$$

The variable *c* is a constant. The terms α_s are indicators for the census tracts in which the properties lie. Alone, they control for time-invariant characteristics of neighborhoods. Most census tracts are small, so in general the tract indicators do a good job controlling for location; the median census tract is only .71 square miles in area. Tract areas range from 0.16 to 2,181 square miles, and ten of our 224 census tracts have land areas over 100 square miles. Despite the large size of some of the tracts, the observations are clustered close to the Las Vegas metropolitan area, and the terms α_s are good indicators for location. The appendix maps the observations and reports the results of a repeat sales approach that controls even more carefully for location.

The terms γ_t are year indicators, and they control for broad trends in the Clark County housing market.[10] Period *m* (the month of sale) falls in year *t*. The vector X_i includes property characteristics that are standard in hedonic models, with coefficients β.

The variable g_m is the log price of gasoline in the month in which the home is sold, and the $g_m \alpha_s$ terms are its interactions with the census tract indicators. Thus the coefficient λ_s is the elasticity of the price of homes in census tract *s* with respect to the price of gasoline. Our focus is on the variation in and spatial patterns of these estimated elasticities. We expect λ_s will be relatively higher in locations that become more attractive when gasoline prices rise (all else equal) and λ_s will be relatively lower in locations that are less attractive when gasoline

[10] Including the interaction of census tract and year indicators is infeasible given the large number of years (35) and tracts (334) in our data.

prices rise. The absolute value of λ_s will be larger in areas most sensitive to gasoline prices, and it will be closer to zero in areas that are insensitive to gasoline prices. Equation 1 imposes no *a priori* restrictions the gasoline-dependent location premia (or discounts) in each tract, such as a particular functional relationship with the distance from central business districts. This function-free approach is appropriate to Clark County, which has multiple major employment centers.

The terms $\mu_s u_m \alpha_s$ help control for macroeconomic fluctuations that may affect home values differently in different neighborhoods. Broad macroeconomic fluctuations could drive both housing demand and oil demand, and that will shift the distribution of our estimated elasticities. By itself, that is not a problem for our study because we are focused on the relative value of homes in different neighborhoods, not area-wide average property values. However, in principle a strong economy could result in higher demand for housing in some neighborhoods than others. Likewise, a weak economy could depress the value of homes in some neighborhoods more than others, while also being correlated with lower gasoline prices. If this occurs, then the estimated coefficients on the location-gasoline price interaction terms could be biased. Thus, we include the terms u_m, measures of the unemployment rate in Nevada in the month of the property sale, interacted with the location indicators α_s. The variable ϵ_{ist} is an error term that reflects random variation in house prices.

Some hedonic studies, particularly those that construct housing price indices, must carefully control for the physical characteristics of homes that are sold to reveal the underlying city-wide trends in home values as an asset class.[11] In our application, as long as we appropriately control for the location of the home, the results of interest are not sensitive to whether the quality of homes or other unobserved characteristics of homes sold vary over time.

It may be the case that when gasoline prices rise, more homes further from the city center are offered for sale while buyer interest in those distant homes wanes. Thus the volume of sales in those areas could on net go up or down, but

[11] Bajari et al (2012) review the issues that arise when omitted attributes are correlated with the observed variables. See Dorsey et al (2010) for more on estimating housing price indices.

either way, prices should unambiguously fall. The hedonic model could fit transactions in one neighborhood in a year better than another neighborhood in that same year. If so, errors would not be independent and identically distributed; the OLS estimates would be unbiased but the standard errors would be wrong. To address this, we estimate robust standard errors, and we cluster the errors by tract-year.[12]

3. DATA

This study combines data on property transactions with data on gasoline prices. In addition, we use data on the unemployment rates in Nevada from the U.S. Bureau of Labor Statistics.

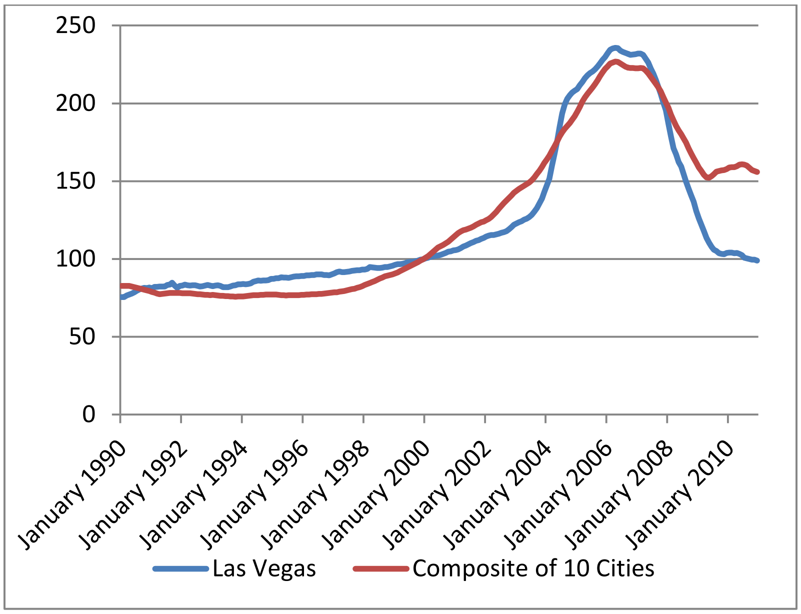
A. Property data

We use data from about 931,000 arms' length home sales in Clark County, Nevada, from January 1976 to December 2010, obtained from the Clark County Assessor's Office. Clark County is an extreme example of the boom and bust U.S. housing market experience, and real home prices exhibit strong variation. The population of Clark County grew dramatically over the duration of the data, with an average annual growth rate of 5 percent from 1990 to 2009. The county population more than doubled from about 780,000 in 1990 to more than two million in 2009.[13] To illustrate the broad market context of our study, Figure 1 shows the S&P/Case-Shiller Home Sales Price Indices for Las Vegas and a broader Case-Shiller composite index for ten large U.S. cities. The boom was steeper and the freefall in 2008 was more dramatic in Las Vegas than in most other cities.

[12] Nichols and Schaffer (2007)

[13] Population data downloaded from Clark County Assessor on September 22, 2010, from http://www.accessclarkcounty.com/depts/comprehensive_planning/demographics/Pages/Demographics.aspx.

FIGURE 1. S&P/CASE-SHILLER HOME PRICE INDICES, JANUARY 1990 TO DECEMBER 2010



Notes: Data for this figure are the S&P/Case-Shiller Seasonally Adjusted Home Price Index Levels, downloaded August 2, 2011, from http://www.standardandpoors.com/indices/sp-case-shiller-home-price-indices/en/us/?indexId=spusa-cashpidff--p-us----.

Each unit of observation in the data is the sale of a residential property. The data include the actual selling price of the property, the sale date, and detailed characteristics of the home. As shown in TABLE 1, the property characteristics include lot size, square footage of living area, number of full baths, the age of the home at the time of sale, and indicators for amenities such as a pool.

TABLE 1.–SUMMARY STATISTICS

Number of Observations = 930,702

	Mean	Standard Deviation	Min	Max
Property price ($)	245,019	146,315	40,005	2,309,211
Living space (ft^2)	1,904	759	280	7,988
Lot size (acres)	.16	.15	.01	5
Home age (years)	9.32	12.48	0	109
Pool indicator	.21	.41	0	1
Full bathrooms	2.19	.58	1	6
Foreclosure indicator	.063	.244	0	1
Townhouse indicator	0.07	0.26	0	1
Multiplex indicator	0.01	0.09	0	1
Price per gallon of gasoline ($)	2.18	0.62	1.22	4.08
Nevada state-level unemployment rate (%)	6.44	3.16	3.8	14.9

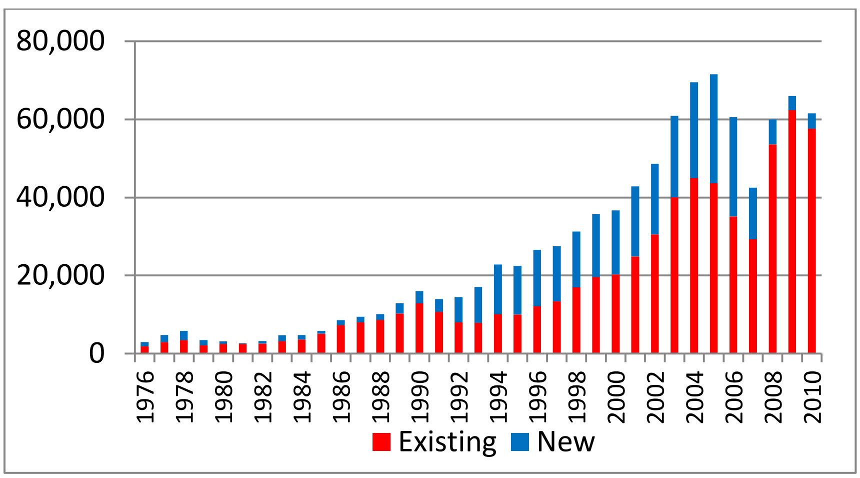
Notes: All dollar values appear in 2010 dollars, deflated using the Consumer Price Index for All Urban Consumers. The data set combines information from the Clark County Assessor's Office, the U.S. Census, and the U.S. Energy Information Administration.

We also include an indicator for transactions the Clark County Assessor designates as linked to a foreclosure. Campbell et al (2011) note that illiquidity in the housing market can depress prices of forced sales. Using data from over 1,800,000 home sales in Massachusetts from 1987 to March 2009, they find foreclosed homes sold at substantial discounts relative to other sales, about 27 percent less on average. We therefore include an indicator in this study to estimate a similar average discount for the Clark County foreclosure transactions from 1976 through 2010.

We removed outliers from the data as detailed in the Appendix. For example, given the specialized market for such properties, we exclude very large homes (greater than 8,000 sq. ft. of living area) and homes on very large lots (greater than five acres). We also drop sales of properties with prices under $40,000 or over $5 million ($2010). These dropped observations collectively represent 4.6 percent of the raw dataset.

FIGURE 2 shows the distribution of the remaining 930,702 observations by year of sale from 1976 to 2010, with sales of new homes in blue and existing homes in red. The observations are heavily weighted towards the past two decades for two reasons. First, new home sales grew dramatically from the mid-1990s through 2006, as evidenced by the heights of the blue bars. Second, the Clark County database includes only the three most recent transactions for each property. Thus, although we observe some sales back to 1976, those observations are only of homes that were not subsequently sold more than two additional times by the end of 2010.

FIGURE 2. NUMBER OF OBSERVATIONS BY YEAR OF SALE, NEW AND EXISTING HOMES



B. Gasoline prices

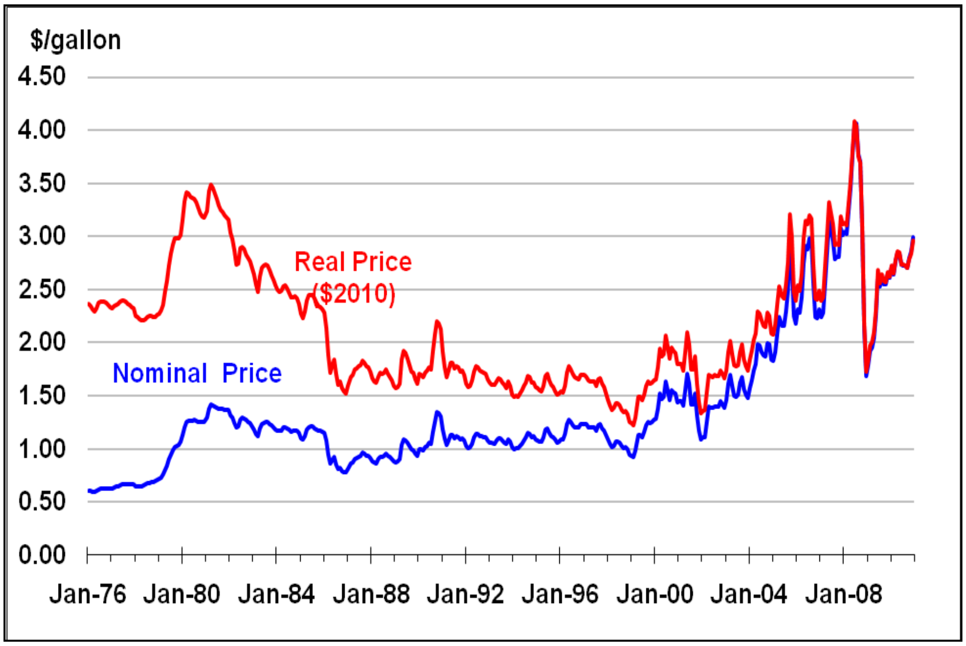
Many hedonic studies infer the implicit price function for non-market factors such as air quality and natural open space. In that context, consistent estimation is difficult because unobserved factors (such as crime rates) could covary with both the non-market factors and housing prices.[14] Here, one might be concerned that, say, seasonality in gasoline prices and seasonality in housing markets could produce spurious correlation and compromise the interpretation of our estimated coefficients. Gasoline prices show the expected seasonal pattern of systematically higher levels in summer months, but property sales prices in Clark County, Nevada, do not show a strong seasonality -- less than one percent variation in sales price by calendar month of sale. The climate, the large share of new home sales in the data, and the attractiveness of Las Vegas for retirement and second homes could all contribute to this.[15]

Potential misspecifications could also arise with local gasoline prices, which are a function of specific neighborhood characteristics, such as the scale and competitiveness of the local retail economy. We avoid this problem by using national average gasoline prices, which are unaffected by neighborhood characteristics in Clark County, Nevada. Another reason to use national gasoline prices in this study is that a key goal of this paper is to understand how national climate and energy policies can affect local housing markets. In that context it makes sense to exclude within-city gasoline price deviations, which are unlikely to be affected by national or state-level energy policy. FIGURE 3 shows the U.S. national average of gasoline prices from the U.S. Energy Information Administration (EIA) in nominal and 2010 dollars. The figure shows significant variation in real gasoline prices over the period of this study, from a low of $1.22 in February 1999 to a high of $4.08 per gallon in June 2008.

[14] For example, see Gayer et al (2002). Chay and Greenstone (2005), Halvorsen and Pollakowski (1981), and Cropper et al (1988) discuss the challenges of misspecification of hedonic price models.

[15] We estimated Equation (1) both with and without calendar month indicators and find that they add no appreciable explanatory value.

FIGURE 3. MONTHLY U.S. AVERAGE MOTOR GASOLINE RETAIL PRICE, JANUARY 1976 TO DECEMBER 2010



Notes: Data for gasoline prices are from EIA's *Short-Term Energy Outlook - Real Energy Prices* data series, February 2011 update. See http://www.eia.gov/EMEU/steo/realprices/index.cfm. Prices are for regular grade gasoline.

Households should consider the *expected* price of gas when deciding how far to live from work. Empirically, however, the current level of gas prices appears to be a good proxy for the expected future price.[16] Anderson et al (2011) find that the average consumer expects the future real price of gasoline to equal the current price, and consumers exhibit a reasonable forecast in most instances.

4. RESULTS

A. Hedonic Model

Table 2 reports the estimation results of a model that includes log gas prices and Nevada unemployment rates, but not their interactions with location indicators.

[16] Molloy and Shan (2010), Alquist and Kilian (2010), Bopp and Lady (1991), and Chinn and Coibion (2010)

TABLE 2.– MODEL WITHOUT INTERACTIONS
DEPENDENT VARIABLE: LN(PROPERTY SALE PRICE)

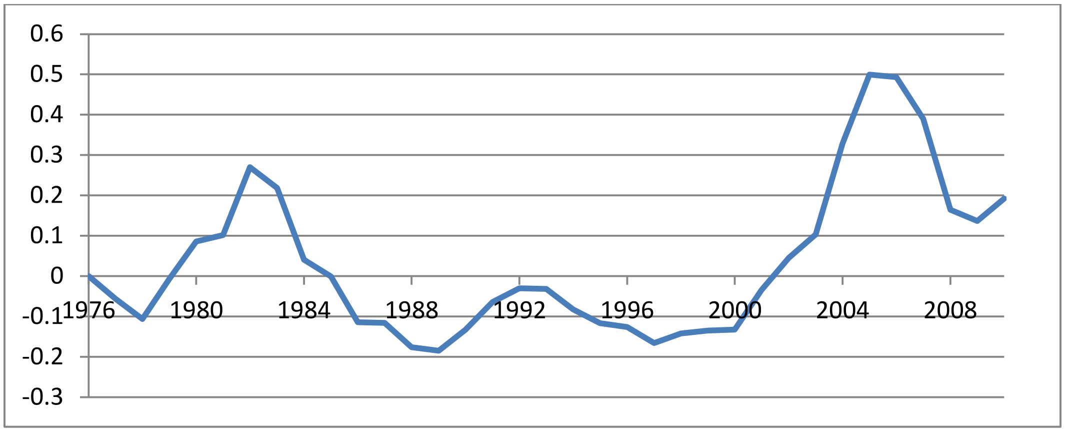
Explanatory Variable	Estimate		Robust Std. Err.	t	P>|t|	95% Conf. Interval	
Constant	8.288	***	0.0502	165.03	0.000	8.1893	8.3862
ln(gasoline price)	0.051	***	0.0075	6.71	0.000	0.0358	0.0653
Nevada unemployment rate (in percent)	-0.049	***	0.0014	-33.68	0.000	-0.0515	-0.0458
ln (Square footage of home)	0.579	***	0.0051	112.65	0.000	0.5693	0.5894
ln(Lot size in acres)	0.141	***	0.0040	35.50	0.000	0.1327	0.1483
Age	-0.007	***	0.0003	-23.09	0.000	-0.0081	-0.0068
Age*Age	0.000		0.0000	-0.39	0.697	0.0000	0.0000
Pool indicator	0.066	***	0.0012	54.02	0.000	0.0639	0.0687
Number of full baths	0.027	***	0.0018	15.31	0.000	0.0238	0.0308
Multiplex indicator	-0.032	***	0.0088	-3.60	0.000	-0.0488	-0.0144
Townhouse indicator	0.000		0.0049	0.05	0.957	-0.0094	0.0100
Foreclosure indicator	-0.147	***	0.0047	-31.51	0.000	-0.1560	-0.1377
Year indicators (shown in Figure 4)							Yes
Census tract indicators (count = 335)							Yes
Census tract indicators interacted with ln(gasoline price)							No
Census tract indicators interacted with Nevada unemployment rate in sale month							No
Number of observations =							930702
R-squared =							0.810
Root MSE =							.227

Asterisks ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Dollar values are in real $2010. Standard errors are clustered by tract-year, with a total of 9759 distinct groups.

The coefficient in Table 2 on the log of gasoline prices suggests that a one percent increase in the real gasoline price is associated with a .05 percent increase in home values. This likely reflects a small broad positive relationship between gasoline prices and home prices via macroeconomic conditions, even when controlling for state unemployment rates. In other words, when economic growth is strong, so are both home values and demand for transportation fuel. A spatially systematic variation in this correlation could lead to spurious results when we interact gasoline prices with location indicators. For example, home values in the urban core could be relatively more closely tied to a cyclical tourist economy than homes on the outskirts of town, and thus be more positively related to gasoline prices. Ideally, we would employ an instrument for gasoline prices that is uncorrelated with macroeconomic conditions, but such an instrument is elusive. Rather we simply note that the magnitude and distribution of the estimated elasticities may be skewed if home values in some neighborhoods are more procyclical than in others, even when controlling for state-wide macroeconomic conditions.

The other estimated coefficients on the housing characteristics shown in Table 2 are broadly consistent with other hedonic studies such as Walls et al (2013). For example, the results suggest that a one percent increase in the square footage of the home, all other factors equal, translates into about a 0.6 percent increase in the sales price of the property. The estimated coefficient on the foreclosure indicator suggests that distressed property sales produce a 13.5 percent lower selling price than other sales of comparable properties. Our result is smaller but of the same order of magnitude as the results of Campbell et al (2011), who estimated foreclosure discounts on average of 27 percent on 1.8 million house transactions in Massachusetts from 1987 through March 2009. Figure 4 shows the year indicators in the model in Table 2. From 1990 on, they track the Case-Shiller indices in Figure 1, with the exception that the year indicators in our model show a dip in the mid-1990s.

FIGURE 4. YEAR-SPECIFIC EFFECTS IN MODEL IN TABLE 2, 1976 TO 2010



Notes: This graph reports the year specific effects in the model reported in Table 2. The values on the vertical axis indicate the overall change in real prices of properties sold relative to 1976.

As discussed above, the variance of the error term may not be constant for a number of reasons, including because the fit of the model could be systematically worse for certain property sub-markets than others. For example, Goodman and Thibodeau (1997) demonstrate strong heteroscedasticity in hedonic housing price models that is related the age of the dwelling. We conducted a Breusch–Pagan test, which confirmed heteroscedasticity. We estimate robust standard errors and cluster the errors by tract-year.

Table 3 reports the estimation results of our core model, which includes interactions between the price of gasoline and state unemployment rates with location indicators. The coefficients on the hedonic variables show little difference from the model in Table 2.

TABLE 3.—MAIN RESULTS: MODEL WITH LOCATION INTERACTIONS
DEPENDENT VARIABLE: LN(PROPERTY SALE PRICE)

Explanatory Variable	Estimate		Robust Std. Err.	t	P>|t|	95% Conf. Interval	
Constant	8.512	***	0.064	131.9	0.000	8.3856	8.6386
ln (Square footage of home)	0.577	***	0.005	113.86	0.000	0.5670	0.5869
ln(Lot size in acres)	0.144	***	0.004	36.62	0.000	0.1366	0.1520
Age	-0.009	***	0.000	-30.48	0.000	-0.0094	-0.0083
Age*Age	0.000	***	0.000	6.18	0.000	0.0000	0.0000
Pool indicator	0.068	***	0.001	55.09	0.000	0.0652	0.0700
Number of full baths	0.027	***	0.002	15.46	0.000	0.0235	0.0303
Multiplex indicator	-0.021	***	0.008	-2.58	0.0100	-0.0375	-0.0051
Townhouse indicator	0.002	*	0.005	0.44	0.659	-0.0074	0.0117
Foreclosure indicator	-0.134	***	0.004	-33.23	0.000	-0.1420	-0.1262
Year indicators						Yes	
Census tract indicators (count = 335)						Yes	
Census tract indicators interacted with ln(gasoline price)						Yes	
Census tract indicators interacted with Nevada unemployment rate in sale month						Yes	
Number of observations =						930,702	
R-squared =						0.819	
Root MSE =						0.222	

Notes: Asterisks ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Dollar values are in real $2010. Standard errors are clustered by tract-year, with 9758 distinct groups.

Tables 4 and 5 report summary statistics on the estimated elasticities, and Figure 5 is a histogram of the values. The elasticities of home prices with respect to gasoline prices range across the set of 335 census tracts from -.77 to 1.09, with an (un-weighted) mean value of .06.

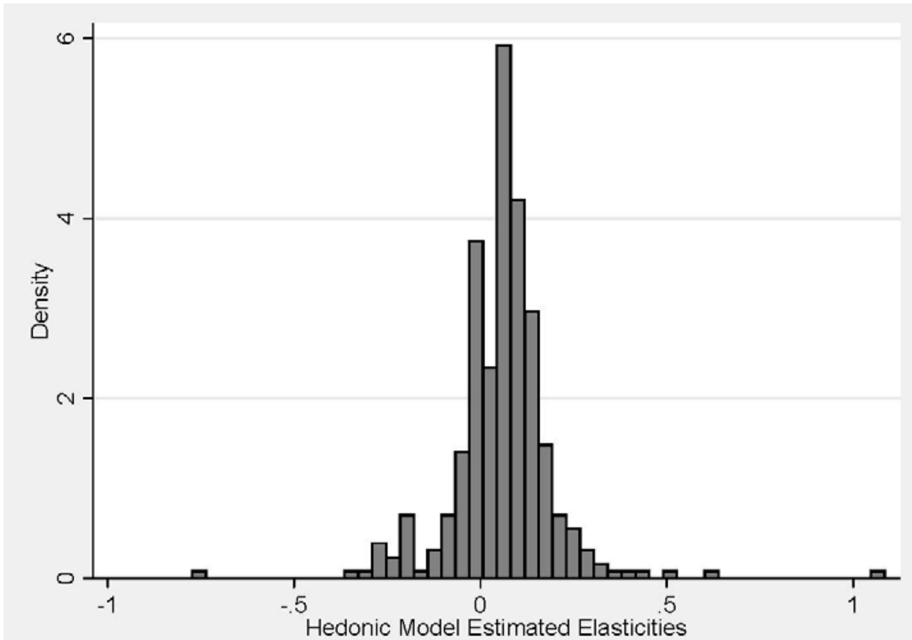
TABLE 4.−DESCRIPTIVE STATISTICS OF ESTIMATED ELASTICITIES

Number of Observations = 335				
Variable	**Mean**	**Standard Deviation**	**Min**	**Max**
Interaction of Census Tract indictors and Property price	0.0607	0.1388	-0.7731	1.0854
Interaction of Census Tract indictors and Nevada state-level unemployment rate (%)	-0.0511	0.0193	-0.0905	0.0246

TABLE 5. − CENTILES OF 335 ESTIMATED GASOLINE PRICE ELASTICITIES

Percentile	10	20	30	40	50	60	70	80	90
Centile Value for Elasticity	-0.078	-0.014	0.023	0.051	0.066	0.086	0.107	0.134	0.183

FIGURE 5. HISTOGRAM OF ESTIMATED GAS PRICE ELASTICITIES IN 335 CENSUS TRACTS: HEDONIC MODEL



A few of the estimated coefficients in Figure 5 have implausibly large absolute values. For example, three tracts have estimated elasticities in excess of .5, meaning that a 10 percent increase in the price of gasoline is associated with an increase the home value of 5 percent.[17] Another tract recorded an implausibly low elasticity of -0.773.[18] In most of these cases, a large share of a relatively low number of tract-level observations occurred in a one or two-year timeframe.[19] Such temporally concentrated observations can produce anomalous coefficients as a result of coincidental moves in gas prices and home values.

Abstracting from implausible tail estimates, we find that the 10th and 90th percentiles of the estimated elasticities are -0.08 and 0.18, respectively. This means that a ten percent increase in the price of gasoline is associated with a

[17] These elasticities are 0.506 for tract 2962, 0.625 for tract 5609, and 1.085 for tract 2602.

[18] Tract 2506

[19] To illustrate, 27.55 percent of tract 2602's 98 home sales occurred in 2007. 25.8 percent of the population of only 310 home sales that took place in Tract 5609 occurred in 2003-2004.

range of home price changes between about negative one percent to positive two percent.

The estimated elasticities for each of the tracts are illustrated in the graduated color maps in Figure 6 and Figure 7.

FIGURE 6. ESTIMATED ELASTICITIES OF PROPERTY PRICES WITH RESPECT TO GASOLINE PRICES: CLARK COUNTY, NEVADA

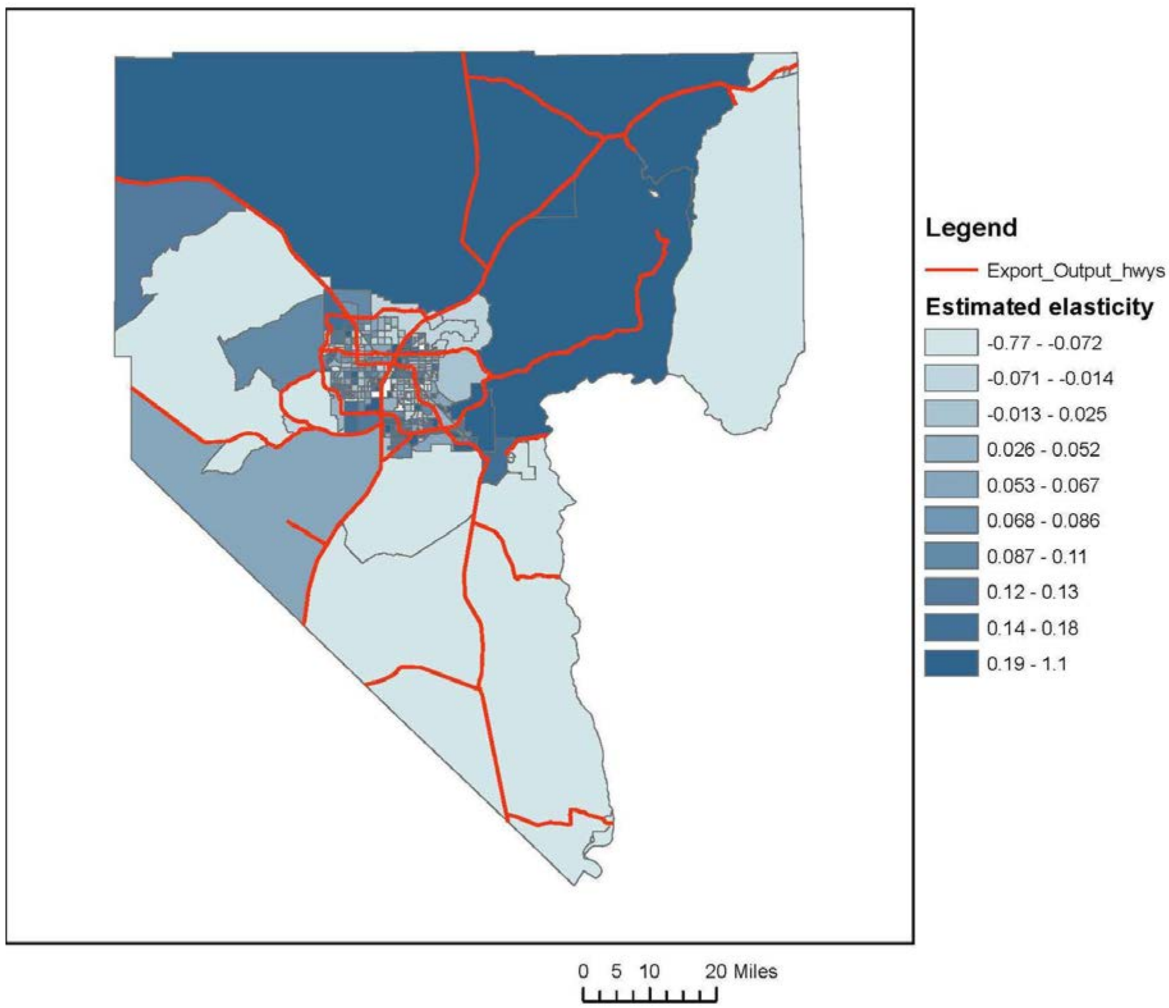
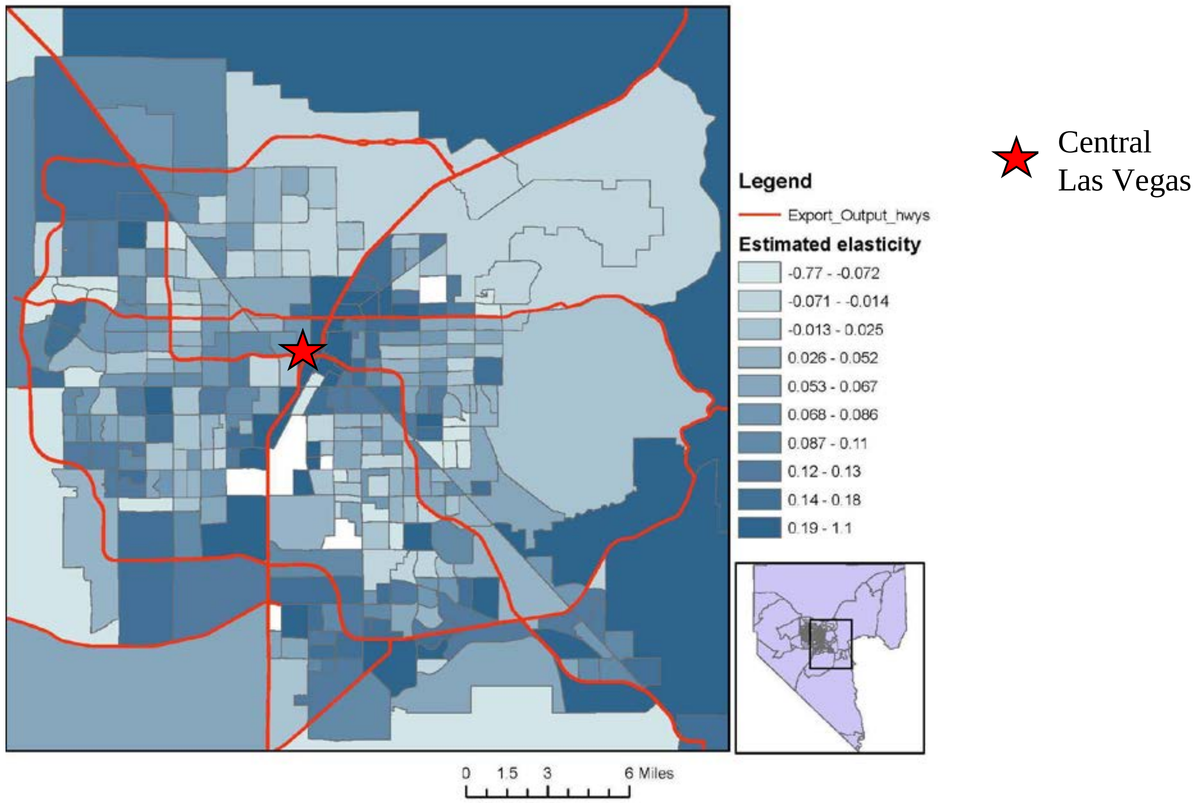


FIGURE 7. HEDONIC MODEL'S ESTIMATED ELASTICITIES OF PROPERTY PRICES WITH RESPECT TO GASOLINE PRICES: CENTRAL CLARK COUNTY (LAS VEGAS, NORTH LAS VEGAS, AND HENDERSON)



The color of each tract is coded to its estimated elasticity of property prices with respect to gasoline prices, with each color comprising ten percent of the tracts. Major highways appear in red. Figure 7 reports the same information as Figure 6, zooming in on central Clark County. The red star in Figure 7 is an intersection of major highways labeled "central Las Vegas." The Las Vegas strip lies on a diagonal directly below that point towards the southwest. White areas are tracts in which there are no property transactions in our data, and they include McCarran International Airport, the University of Nevada Las Vegas, and areas dense in hotels and casinos.

The figures and maps show a wide range of estimated elasticities. Some areas of higher elasticities (darker areas) appear in the urban core of Las Vegas and some higher elasticities ring the city along major highways. There are also darker patches near other cities within Clark County, such as Henderson and North Las Vegas. Figure 8 maps the location of these cities.

FIGURE 8. CENTRAL CLARK COUNTY: LAS VEGAS, NORTH LAS VEGAS, AND HENDERSON[20]

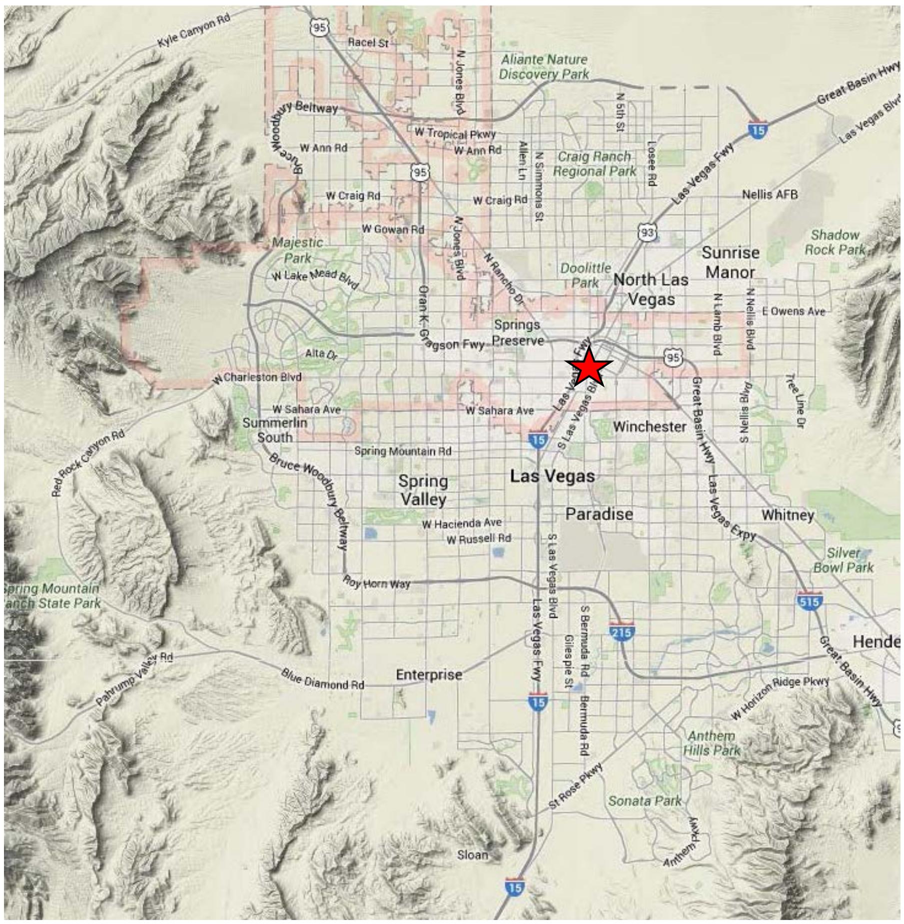


Figure 7 shows a notably dark strip of relatively high and positive elasticities running from the southwest to the northeast diagonally through the Las Vegas strip area. Mean elasticities appear to fall in distance from the strip, and elasticities in rural areas are generally small or negative, as shown by the lightest

[20] Las Vegas, Google Maps, Downloaded February 7, 2014.

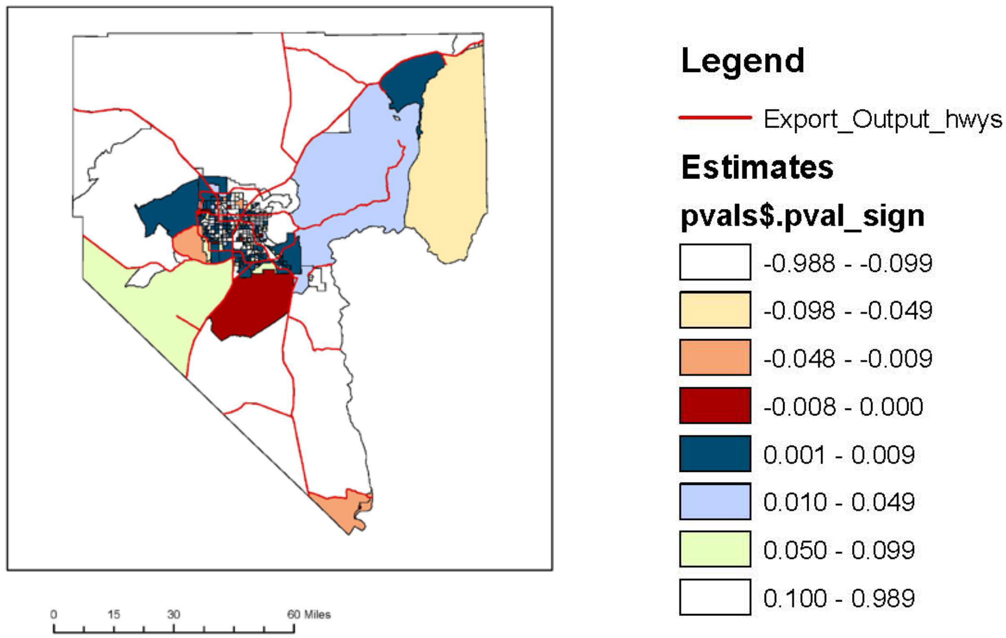
blue areas. The color pattern is broadly consistent with the hypothesis that the relative values of properties in areas closer to the city center are more positively correlated to gasoline prices, but the map also indicates some differences between estimated elasticities even across adjacent tracts.

A few of the very rural tracts report relatively high elasticities, as shown by their dark blue color. Some of these tracts have very few observations, and a number of these elasticities, although relatively large, are not statistically different from zero at a 90 percent confidence interval. The pattern of declining elasticity from the urban core is even more pronounced in the repeat sales results, discussed in the Appendix, than it is in Figure 7. This is consistent with the more recent profile of sales in the repeat sales dataset.

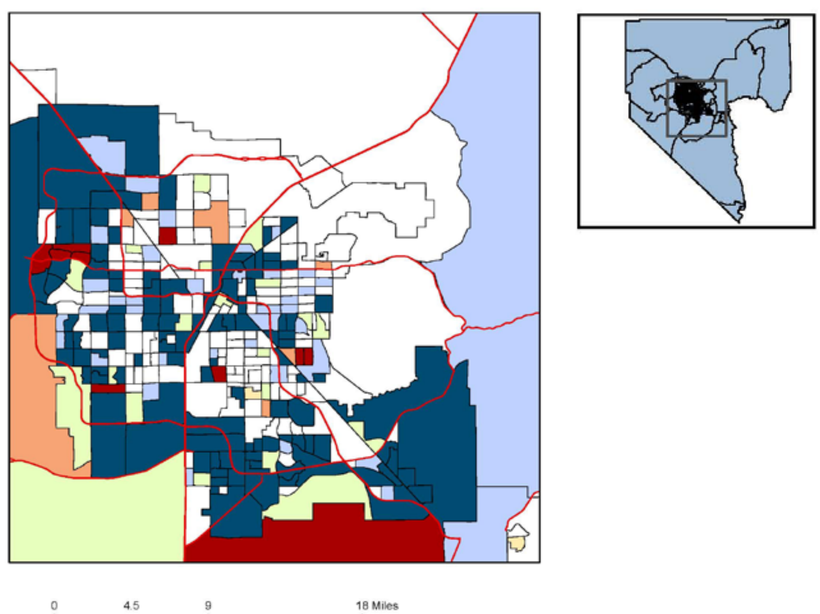
FIGURE 9 reports the P-value of the estimated elasticities. The white tracts are those with an estimated elasticity that is not statistically significantly different from zero at the 90 percent confidence level or lower, meaning that one cannot reject the hypothesis that gasoline has no effect on home values. The darkest blue and red tracts are those in which we reject the null that the elasticity is zero with a 99 percent or higher degree of confidence with positive and negative elasticities, respectively. The two intermediate colors (orange and yellow for negative elasticities; light blue and green for positive elasticities) represent confidence levels of 95 to 99 percent and 90 to 95 percent, respectively.

FIGURE 9. P-VALUES OF ESTIMATED GASOLINE PRICE ELASTICITIES

PANEL A



PANEL B



The maps suggest that the results with the greatest (positive) statistical significance, the dark blue areas, are those closest to the city center and to the west and south of Las Vegas around the Highway 215 corridor. The most statistically significant and negative elasticities are one large tract to the south of the metropolitan area and a cluster to the west, which is surrounded by tracts with negative and highly statistically significant elasticities.

Owing to small number of transactions, some of the very rural and mid-city tracts do not show a statistically significant relationship between gasoline prices and home values despite having relatively large estimated elasticities in absolute value.

The spatial pattern of the elasticities is partly consistent with the theory that the values of closer-in homes tend to be more positively related to gasoline prices than further-out homes within the same housing market, but the effect is far from a simple monotonic relationship with distance from the urban core. The confidence around the results is particularly strong for central and suburban areas, but elasticities in adjacent areas do not necessarily have the same sign or significance.

The results described so far indicate that gasoline prices do indeed affect home values in a significant share of neighborhoods across the county. We now turn to question of the extent to which the estimated elasticities in different tracts are significantly different *from each other*. To get at that, we conducted a full set of 55,945 unique pairwise F tests, each one testing a hypothesis that a particular estimated elasticity is equal to another.[21] The color-coded results appear in a (necessarily) symmetric 335 by 335 matrix in Figure 10. As a simple organizing format for the matrix (but not pertinent to the econometric approach), we calculated the mean longitude and latitude coordinates for the observations within each tract (i.e., the "center" of the tract). Then we sorted the tracts by the distance of their center to central Las Vegas. Thus, the upper left hand corner of the matrix reports the P-values of the center-city tracts compared to each other and the lower right shows the results of the most rural tracts

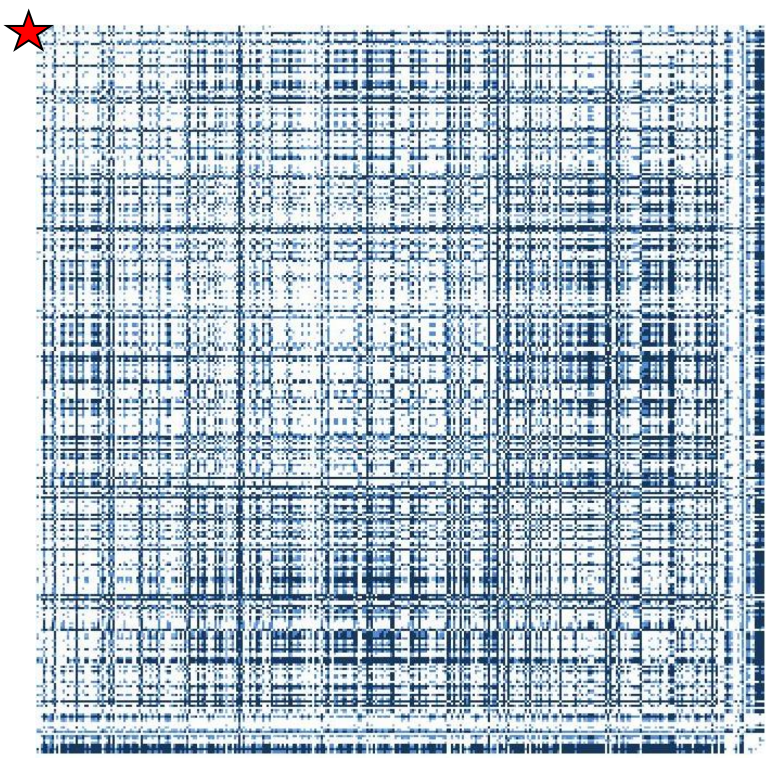
[21] The number of unique pairs of census tracts is given by (335 x 334)/2 = 55,945.

compared to each other. The P-values of the pairwise F-tests fall into blue confidence/color categories similar to the map in Figure 9, with the darkest elements representing a 99 percent confidence level that the estimated elasticities are statistically significantly different from each other and the white elements representing a confidence level below 90 percent.

FIGURE 10. PAIRWISE F-TEST P-VALUES OF ESTIMATED GASOLINE PRICE ELASTICITIES

Legend

Range of P Value of F test	Fill Color
P > .1	
.1 ≤ P < .05	
.05 ≤ P < .01	
P < .01	



Notes: Rows and columns are 335 census tracts sorted by distance to central Las Vegas. Thus the upper left tests tracts close to central Las Vegas against each other, and the lower right tests exurban tracts against each other.

The upper right and lower left areas of the Figure 10 matrix show the urban tracts compared to the rural tracts. Those areas appear generally darker, informally supporting the intuition that property values in the urban core and rural/exurban areas tend to have significantly different relationships with gasoline prices. But the figure also shows that significant differences arise across neighborhoods equidistant from the urban core.

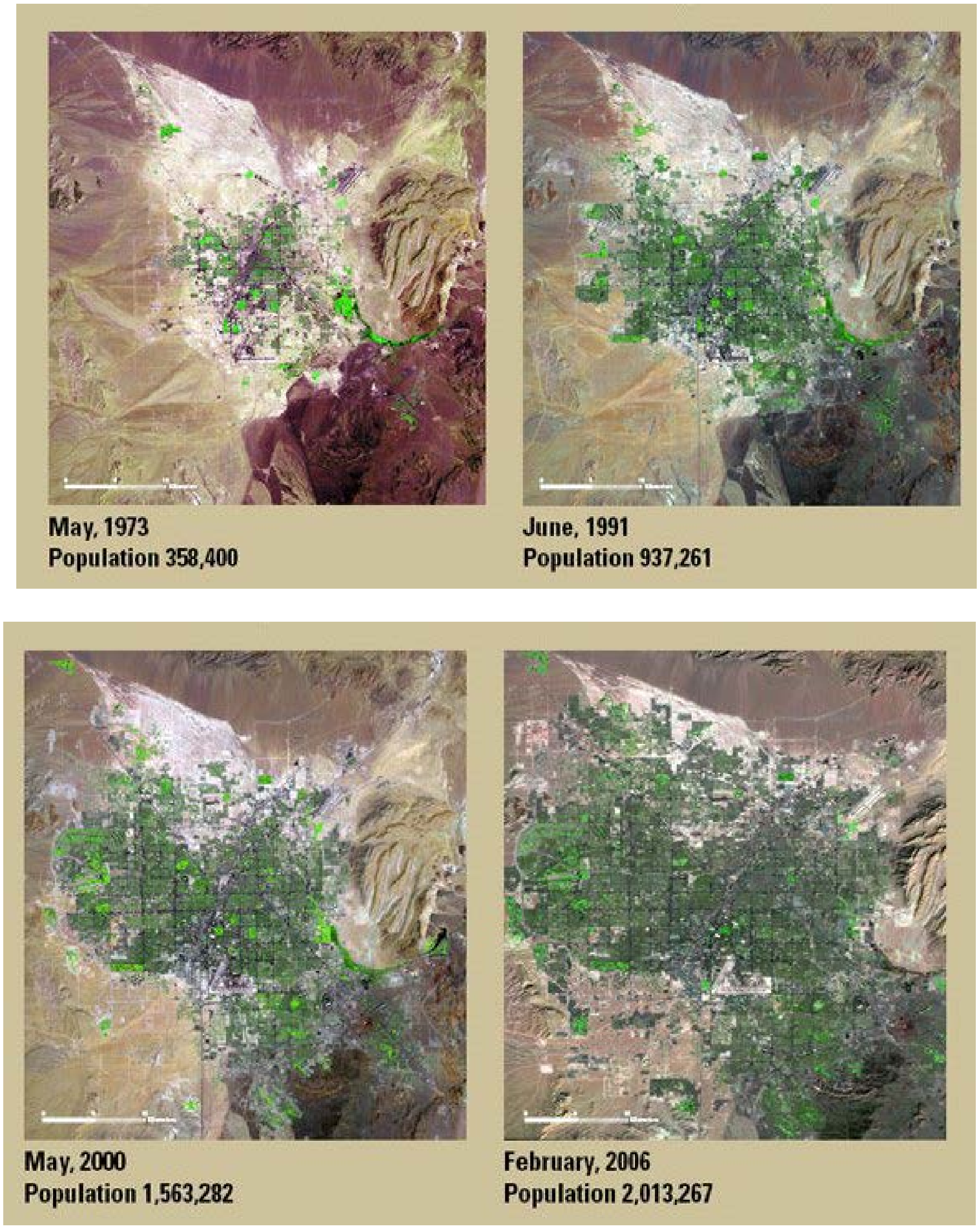
B. Elasticities in Sub-Periods

The relationship between home prices and gasoline prices may have changed through the 35 year period of our data. Certainly, the spatial pattern of employment centers and housing developments has shifted significantly in Las Vegas since the 1970s. From 1974 to 2010, the Clark County population grew by over 580 percent, and major developments arose in the Las Vegas suburbs of Summerlin, Green Valley, and Henderson.[22] Figure 11shows the extraordinary growth of the Las Vegas area in satellite images from 1973 to 2006.[23] Moreover, as Hughes et al (2008) note, factors such as Corporate Average Fuel Economy (CAFE) standards, the growth of multiple income households and per capita disposable income, and the evolution in public transit have changed the responsiveness of U.S. consumers to changes in gasoline prices. Households may also have shifted their beliefs about the extent to which changes in gasoline prices are likely to persist.

[22] http://www.lasvegasnevada.gov/files/PopulationEstimate.pdf

[23] http://www.nasa.gov/images/content/202842main_lasvegas_lg.jpg

FIGURE 11. SATELLITE MAPS OF LAS VEGAS IN 1973, 1991, 2000, AND 2006



To see whether the pattern of estimated elasticities has changed substantially over time, we conducted six hedonic regressions of overlapping 10-year sub-periods of the data, inclusive of the years: 1976-85, 1981-90, 1986-95, 1991-2000, 1996-2005, and 2001-2010. The first six panels of Figure 12 show histograms of the estimated price elasticities of home values with respect to gasoline prices in those sub-periods of the data, following the estimation model reported in Table 3.

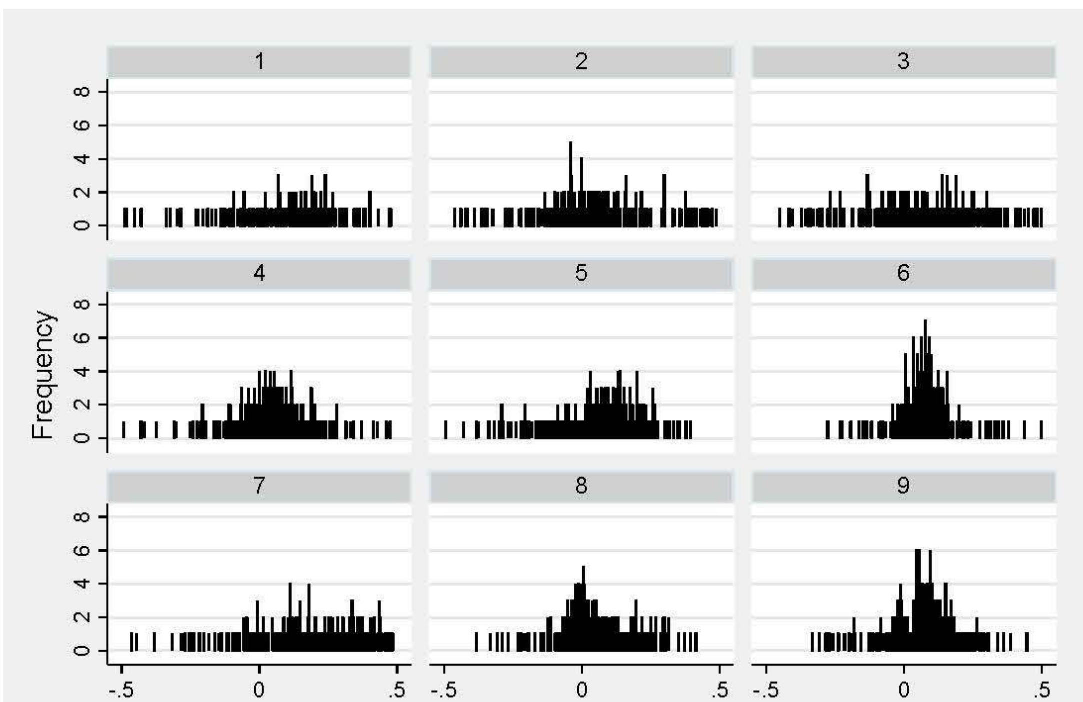
FIGURE 12. HISTOGRAMS OF PROPERTY PRICE-GAS PRICE ELASTICITIES, SUB-PERIODS (VALUES FROM -0.5 TO 0.5 SHOWN)

PANEL 1: (1976-85); 2: (1981-90); 3: (1986-95); 4: (1991-2000); 5: (1996-2005); 6: (2001-2010)

PANEL 7: HOUSING BOOM, FROM JANUARY 2002 TO APRIL 2006 (INCLUSIVE)

PANEL 8: HOUSING BUST, FROM APRIL 2006 THROUGH DECEMBER 2010 (INCLUSIVE)

PANEL 9: FULL SAMPLE, FROM JANUARY 1976 THROUGH DECEMBER 2010



In the early periods, panels one through three, the elasticities are widely dispersed, just shy of a uniform distribution. By the 1990s (panel four), the elasticities begin to show a more strongly normal distribution centered between 0 and 0.1. By the last decade (panel six) of 2001 to 2010, the elasticities fall in a much narrower distribution, with a density strongly concentrated in the 0 to 0.1 range. This suggests that the broad sensitivity (positive and negative) of home prices to contemporaneous gasoline prices has fallen significantly over the period of our data, and the distribution of elasticities has narrowed considerably.

The intensity of the relationship between housing values and gasoline prices may have fallen in part as the overall fuel economy of the vehicle fleet has risen. For example, the average fuel economy of new cars sold in 2010 was over 70 percent higher than new cars sold in 1975.[24] All else equal, we would expect this to dampen the sensitivity of home prices to gasoline prices.

We also ran the regressions with data confined to the months of the Las Vegas housing boom, as defined by the major run-up in the Case-Shiller housing price index from January 2002 to its high in April 2006 (inclusive), and the housing bust from April 2006 to the end of our data in December 2010 (inclusive). Panel seven in Figure 12 shows the elasticities of sales in the months of the housing boom. Panel eight includes sales in the months of the housing bust that followed. The distribution of elasticities in the boom is similar to the almost uniform distribution of earlier periods while elasticities in the bust are more narrowly distributed with a mode near zero. This suggests that the distribution of relationships (not just the average relationship) of gasoline prices to home values could depend on the direction of the economy.

For comparison, panel nine in Figure 12 shows the elasticities of sales for the entire period, the same data that appear in Figure 5. The spatial characteristics (not shown) of the elasticities in later years (panels six through eight) indicate a pattern of declining elasticities from the urban core slightly more pronounced than elasticities in the full period shown in Figure 7. So although the distribution of elasticities in later years is tighter, the overall spatial pattern of elasticities we

[24] EPA (2013). Hughes et al (2008) find that the short-run price elasticity of U.S. gasoline demand is significantly more inelastic in recent years than in the late 1970s.

see for the full sample holds throughout the period and may even intensify in more recent years.

C. *Comparative Statics*

In this section, to assess the potential spread of home values produced by a change in gasoline prices, we estimate the dollar value effect of an illustrative increase of ten percent in gasoline prices on the relative value of homes in different neighborhoods.[25]

For comparison, according to the Energy Information Administration (EIA), H.R. 2454 (the Waxman-Markey climate bill) would have raised gasoline prices by 27 cents per gallon, or 7.6%, in 2020 relative the baseline value of $3.55 (in $2007). Ten percent of the mean gasoline price in our data is about $0.22, a common swing in gasoline prices, and it equates to the implications of a carbon tax of about $22 per ton of CO_2.[26] Such a tax is in the range of recent carbon tax proposals and the social cost of carbon as estimated by the Obama Administration.[27]

To narrow the estimation results to plausible values, we windsorize the sample of elasticities by dropping the highest and lowest two percent. To obtain the change in home values relative to the mean, we subtract the mean elasticity (about 0.06) from all of the estimated elasticities to obtain deviations in elasticities from the mean. Then we multiply all of the deviations in elasticities by ten to obtain the predicted percent change in home values for each tract given an increase in gasoline prices of ten percent, relative to the mean. We evaluate this change at the average property price in each tract to derive the expected dollar level change in home prices, relative to the mean.

Figure 13 shows the graduated color map of the dollar value changes, relative to the mean, for a ten percent ($0.22) increase in gasoline prices in central Clark County. Figure 14 shows the results for the full county. The estimated home price effects range from about -$7,850 to $5,590.

[25] See EIA (2009), page 36, Figure 26.
[26] Ramseur et al (2012), Table 3.
[27] CBO (2013); U.S. Government Interagency Working Group on Social Cost of Carbon (2013)

FIGURE 13. ESTIMATED CHANGE IN PROPERTY PRICES WITH A 10% INCREASE IN GASOLINE PRICES, RELATIVE TO MEAN, OUTLIERS DELETED
CENTRAL CLARK COUNTY (LAS VEGAS, NORTH LAS VEGAS, AND HENDERSON)

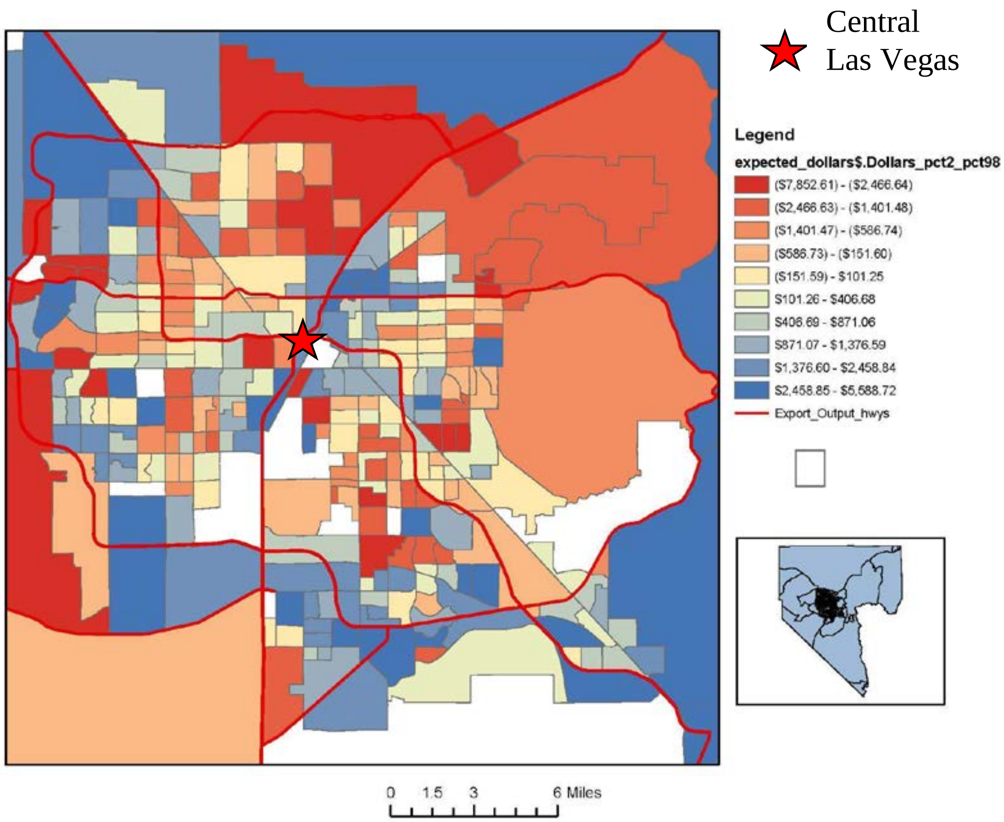
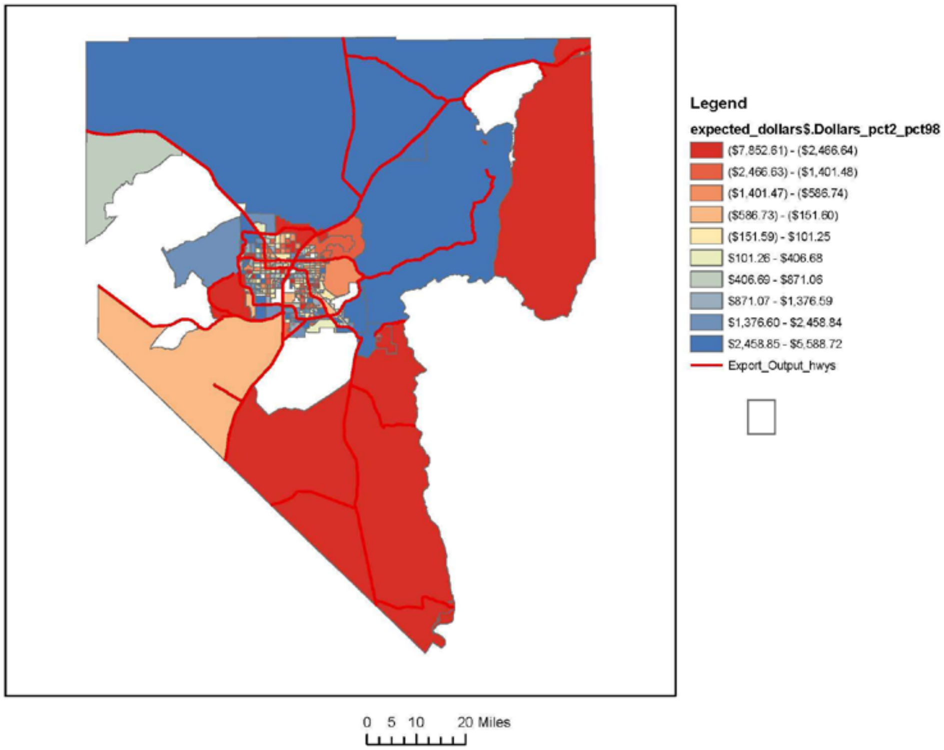


FIGURE 14. ESTIMATED CHANGE IN PROPERTY PRICES WITH A 10% INCREASE IN GASOLINE PRICES, RELATIVE TO MEAN, CLARK COUNTY



The largest negative values are in the northern and southwest suburbs of the city, and the largest positive values are in the urban core and the southern periphery. These results reflect a combination of the magnitude of the elasticities and the mean home values in these areas. Areas near major roads and highways, possibly because they offer easy access to efficient travel paths, tend towards more positive (blue) effects. That said, Figure 13 shows some adjacent neighborhoods that have estimated price effects that are statistically significantly different from zero and of opposite sign. This suggests there could be important unobservables, perhaps such as demographics or access to public transit, that bear on the results.

5. CONCLUSION AND NEXT STEPS

We find that gasoline prices can affect property values in different neighborhoods differently. Using data from 930,702 home sales in Clark County, Nevada, from 1976 through 2010, we estimate the elasticities of property prices with respect to gasoline prices, allowing the effect to vary by census tract. The estimated elasticities range from about -.07 to about 0.18 across the census tracts in the data, meaning that a ten percent increase in gasoline prices can shift relative home values over a range about 2.5 percentage points.

These results suggest gasoline prices may be affecting credit risks, property markets, and household wealth in ways the economic literature has so far not fully recognized. While some studies have found that in general gasoline prices are not significant determinants of home values and foreclosure, our results suggest that there may be significant location-specific risks within metropolitan areas. [28] We see some evidence of this in outlying suburbs but the effect is also important in other areas.

Our investigation of the evolution of the relationship of gasoline prices to home values suggests that the broad sensitivity (positive and negative) of home prices to gasoline prices has fallen significantly since 1976. This could derive in part from the 70 percent increase from 1975 to 2010 in the average fuel economy of new cars sold in the United States.

Our results also bear on the potential distributional effects of a carbon tax or other policy to price greenhouse gas emissions. A ten percent increase in the gasoline price, a change on the order of the short run effects of recent proposed climate legislation, is associated with changes in location-specific average home values that span a range of over $13,000; households with homes near the center of the city and near major corridors would be better off by up to about $5,600, and some households living in the city outskirts would lower mean home values by $7,800, relative to the mean. The net effect on much of the mid-city is

[28] Molloy and Shan (2010), Duling (2008)

small, within $500 plus or minus. However, despite these broad spatial patterns we find instances of significant differences in the effect of gasoline prices even across adjacent neighborhoods. This suggests that location alone is not a perfect predictor of how gasoline prices can affect home values and that there is more to this story left for future investigation.

Our results could be pertinent to other important property markets. Cities with housing supply constraints at least as binding as Las Vegas include, according to Saiz (2010), New York, Los Angeles, Boston, Miami, and San Francisco.

Several extensions to our work are clear. First, given this evidence that gasoline prices do matter, it would be useful to explore potential explanations of the estimated elasticities other than location. For example, tracts with higher mean household income may have property values that are less sensitive to gasoline prices, positive or negative. This could have implications for the distribution by income of the housing wealth effects of a carbon tax. Certainly commuting costs as a share of home value are likely to vary by the overall price point of a neighborhood. Other demographics, such as the share of non-working age adults, might also matter. And tracts closer to employment centers, highways, and public transport could systematically have relatively more positive relationship to gasoline prices. Areas with older homes or greater population density may have less elastic housing supply, and thus be more prone to gasoline price capitalization (positive or negative). Relating the gasoline price effects to neighborhood income levels would also estimate the potential impacts of carbon pricing on households' housing wealth by socioeconomic status.

Another question left open by this study is whether asymmetries in the constraints on housing supply produce asymmetries in the effect of gasoline prices. For instance, housing supply may be more elastic upward than downward, particularly in city outskirts. Thus, outlying areas may experience larger negative downward capitalization when gasoline prices rise than they do positive upward capitalization when gasoline prices fall. Another finding worth investigating further is the different patterns of elasticities in the months of a housing boom and the months of the housing bust depicted in Figure 12.

Finally, a natural extension of our results would be to explore the spatial patterns of the housing bubble collapse in Las Vegas starting in 2006, the worst such implosion in the United States.[29] Cortright (2008) and Kaufman et al (2010) suggest a role of energy prices in declining property market conditions in the post-2005 era. Estimations could show whether Clark County homes in areas with significant negative relationships between home values and gasoline prices were especially prone to foreclosure.

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[29] Las Vegas experienced the worst year-to-year rate of home price decrease to December 2008 in the United States, according to the S&P/Case-Shiller home price index released February 24, 2009, as reported in *Forbes*: http://www.forbes.com/2009/02/24/housing-cities-ten-lifestyle-real-estate_home_prices_slide_21.html?partner=msnre.

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APPENDIX

A. Data discussion

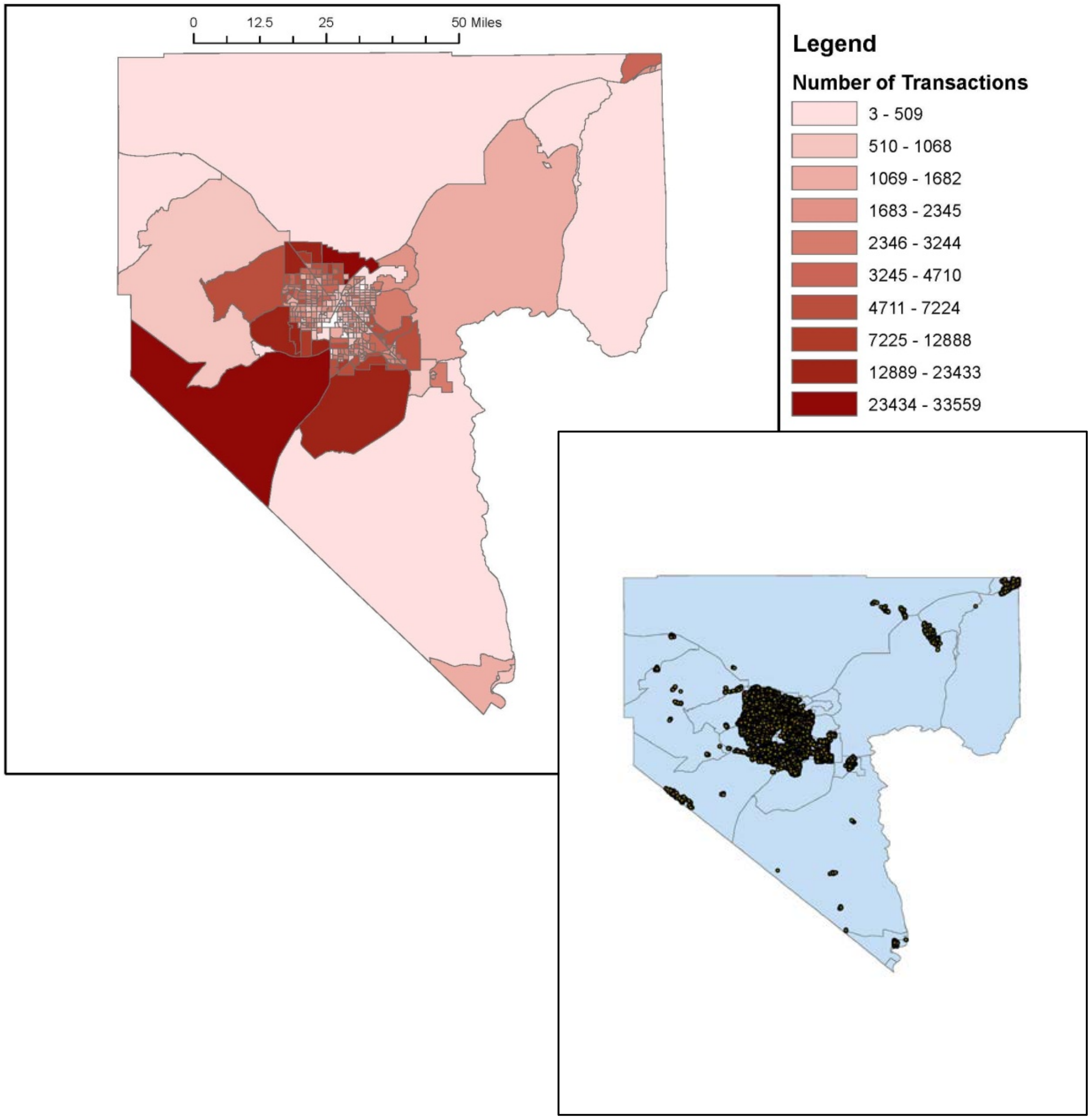
This section discusses the construction of the dataset used in the regressions. This study combines data from three separate data sources. For transaction information, the study uses data from home sales in Clark County, Nevada, from January 1976 to December 2010, obtained from the Clark County Assessor's Office (CCAO).[30] We use the x and y coordinates to map every property to the most recent available census tract boundaries. Thus we ensure that the tract identifier for each property is constant for all the sales of the property in our data, even if the official census tract of the property has changed over time.

The geographic distribution by census tract of the observations in the dataset appears in Figure A. Panel 1 shows that the census tracts with the greatest numbers of property sales in our data are concentrated in central Clark County near the cities of Las Vegas, Henderson, and North Las Vegas. Each dot in the inset of Panel 1 represents the location of a transaction, indicating that transactions within large tracts are generally spatially concentrated in a small area of the tract. Panel 2 shows that within central Clark County, the census tracts with the largest numbers of transactions in our data fall outside the city center of Las Vegas, indicated by the diagonal white and light pink areas in the center left of Panel 2.

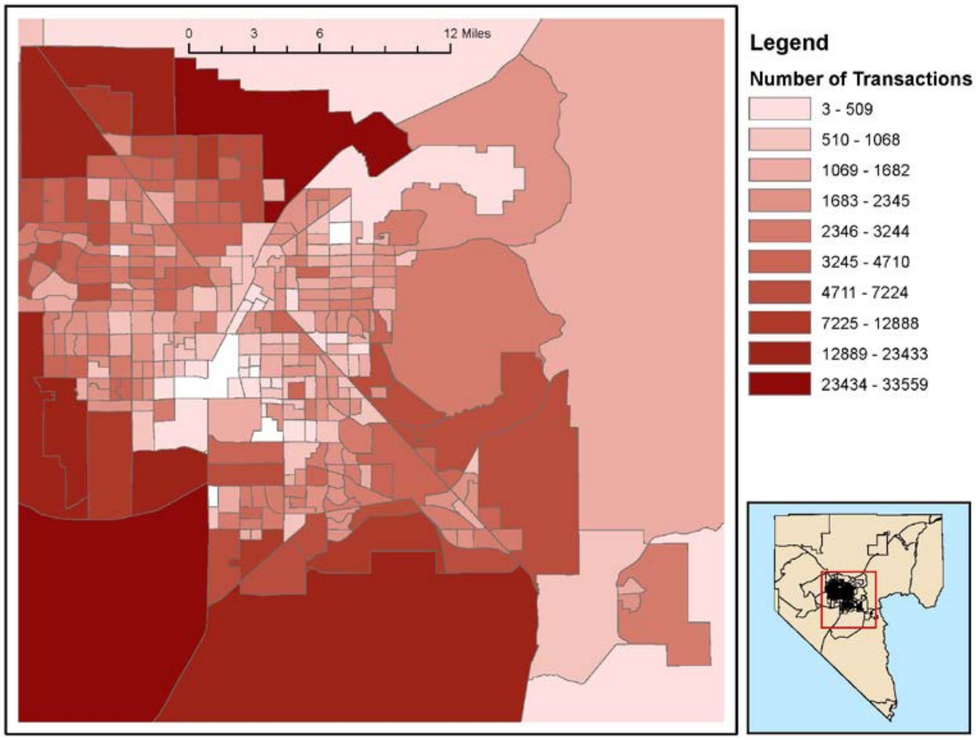
[30] Further documentation on the data set is available at the Clark County Assessor's website. Information about the residential records appears at: http://www.clarkcountynv.gov/Depts/assessor/Pages/ResidentialRecordLayoutInformation.aspx. Information about the specific sales codes appears at: http://www.clarkcountynv.gov/Depts/assessor/Documents/Sales%20Codes.pdf.

FIGURE 15. GEOGRAPHIC DISTRIBUTION OF PROPERTY TRANSACTIONS:

PANEL 1: ALL OF CLARK COUNTY, NUMBER AND LOCATION OF TRANSACTIONS



PANEL 2. -- CENTRAL CLARK COUNTY



We exclude observations that are unlikely to represent ordinary arms' length transactions or vacant land. To do this, we use the CCAO codes that indicate the type of sale for improved properties. Sale types included in the dataset are listed in Table A.1.

TABLE A.1. CCAO SALES CODES INCLUDED IN RAW DATA
(975,584 OBSERVATIONS)

Sale Code	Description
R	Regular sale
Y	Resale in the market range
Z	First time sale in the market range
T	Contract sale, includes land and new construction
N	First time sale or resale above or below market, includes sacrifice, second mortgage, introduction sales
X	Foreclosure resale, tax sale, estate sale in the market range
W	Foreclosure resale, tax sale, estate sale above or below market
M	Sales price is the total purchase price for many or numerous parcels being transferred on the same deed or one purchase price was paid for several parcels conveyed on several deeds.

We constructed a separate foreclosure indicator using the CCAO Foreclosure code. We also create indicator variables for the years in which the transaction occurs and convert all price variables to real 2010 dollars using the Consumer Price Index (All Urban Consumers: U.S. city average deflator) from the U.S. Bureau of Labor Statistics.[31]

We dropped observations with values that suggest the property is likely to be extremely unusual, a non-arms'-length transaction, or coded in error. Thus we drop properties with a real price of less than $40,000 or less than one full bath.

Given the specialized market for such properties, we exclude homes on lots larger than five acres and greater than 8,000 square feet of living space. We also drop sales of homes with prices over $5 million ($2010) or with more than six full baths. We also drop properties with an unusually high price per square foot of over $300 per square foot. The deleted observations collectively represent 4.6 percent of the raw data set.

[31] http://www.bls.gov/cpi/cpid10av.pdf. BLS Table 1A.

Using the year and month of the transaction, we merge the property data with data for the national average gasoline price and the Nevada state unemployment rate. We created logged values for continuous variables, including the sales price of the property, gasoline prices, living area, and lot size. To compute the age of the home in years, we subtract the year of the transaction from the variable in the data that indicates the year the home was built. In some cases the property is sold before the home is built, for example through an advance property sale. In that case we set the age to zero. Home sales with an age of zero appear as "New" in the blue bars of FIGURE 2.

B. Repeat sales alternative model

A repeat sales approach eliminates the problem of omitted variables with respect to time-invariant characteristics of the property. Assuming the changes in housing prices are in percentage terms, we write this log-log model:

1) $$\Delta y_{ist} = \alpha_s + \gamma_t + \lambda_s \Delta g_m \alpha_s + \mu_s \Delta u_m \alpha_s + \epsilon_{ist}.$$

The dependent variable is the difference in the log price of a home from one sale to the next, Δy_{ist}. This is the appreciation of the price of property *i* in census tract *s* over the period between sales. The variable ϵ_{ist} is an error term that reflects random variation in house prices, and the terms α_s are indicators for the census tracts in which the properties lie. The year indicators γ_t in the repeat sales model are a little different than in the hedonic model because we want to control for year effects both in the year of purchase and sale. Thus γ_t is -1 if the home was purchased in year t and +1 if it was sold in year t. This approach ensures that the year-specific effects on home price appreciation are symmetric but of opposite sign, depending on whether the transaction was a purchase or a sale.

The terms $\Delta g_m \alpha_s$ are the change in real log gasoline prices from purchase to sale, interacted with census tract indicators. Likewise, the terms $\mu_s \Delta u_m \alpha_s$ interact the change in state unemployment levels and census tract indicators. Our data report almost no appreciable changes in property characteristics, so Equation 2 does not include a vector of changes in characteristics corresponding to the $\beta' X_i$ in Equation 1. The estimated elasticities of property prices with respect to gasoline prices in the repeat sales model (Equation 2) will not match perfectly the estimated elasticities in the hedonic model (Equation 1). Although arithmetically the two coefficients are the same, only about 442,900 of the approximately 931,000 homes sales in the full dataset are repeat sales, i.e. sales of a property for which we also have data on a prior sale. For example, the repeat sales data exclude all sales of new homes (except as a cost basis for subsequent sales), represented by the blue bars of FIGURE 2, along with the first sale of each non-new property after December 1975. Table A.2 reports the repeat sales data summary statistics and estimation model.

TABLE A.2.– REPEAT SALES MODEL
SUMMARY STATISTICS AND ESTIMATION MODEL

Number of Observations = 442,900

	Mean	Standard Deviation	Min	Max
ΔIn(Property price)	-.047	.484	-2.90	3.46
ΔIn(Price per gallon of gasoline)	.098	.288	-1.04	1.21
ΔNevada state-level unemployment rate (percentage points)	1.49	3.70	-8.4	11.1

DEPENDENT VARIABLE: CHANGE IN LN(PROPERTY SALE PRICE) SINCE LAST SALE

Year indicators for 1977 through 2010 (= -1 if the home was purchased in year t and +1 if it was sold in year t)	Yes
Census tract indicators for 335 tracts	Yes
Census tract indicators interacted with change In(gasoline price) from purchase to sale	Yes
Census tract indicators interacted with change in Nevada unemployment rate from purchase month to sale month	Yes
Number of observations =	442,900
R-squared =	0. 644
Root MSE =	0.290

FIGURE 16 below shows histogram of the estimated elasticities for the repeat sales model. The repeat sales results show a pattern broadly similar to that in Figure 5 for the hedonic model, but with a somewhat greater density in the positive range between 0 and 0.25. This is consistent with the results in Figure 12, panels 5 and 6, which show a generally more positive set of elasticities in the later decades of the data.

FIGURE 16. ESTIMATED ELASTICITIES OF PROPERTY PRICES WITH RESPECT TO GASOLINE PRICES: REPEAT SALES AND HEDONIC MODELS

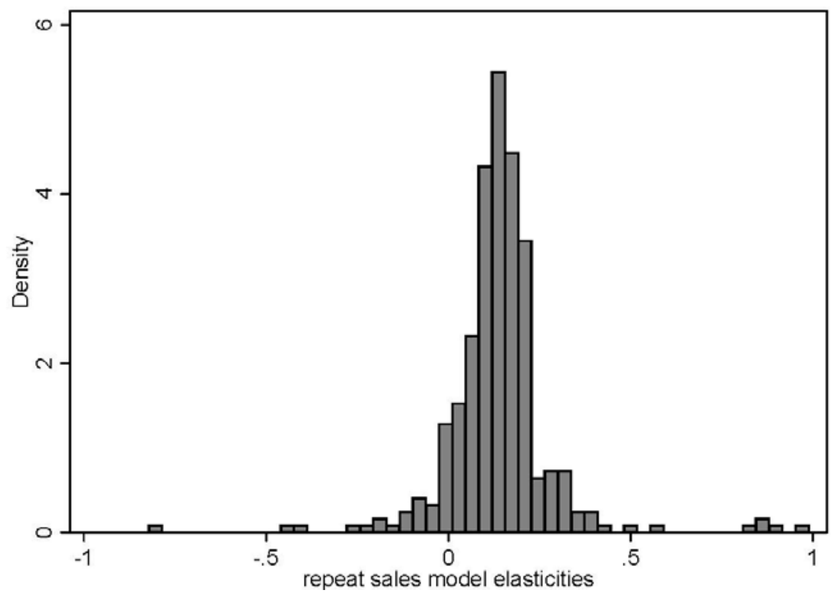


Figure 17 below is a graduated color map of the results from the repeat sales model. The map shows an overall pattern of larger positive elasticities in the urban core and elasticities that are closer to zero or slightly negative in the outskirts. The pattern of declining elasticity from the urban core is more pronounced in the repeat sales map than it is in Figure 7, which maps the results from the hedonic model estimated with the full dataset. This could be due to either the improved control for location inherent in a repeat sales approach, but it is also consistent with the pattern in more recent property sales as discussed per Figure 12.

FIGURE 17. REPEAT SALE MODEL
ESTIMATED ELASTICITIES OF PROPERTY PRICES
WITH RESPECT TO GASOLINE PRICES:
CENTRAL CLARK COUNTY (LAS VEGAS, NORTH LAS VEGAS, AND HENDERSON)