

The King is Dead, Long Live the King?  
The Effects of Power Plants on Housing Prices in the  
Age of Coal-Switching

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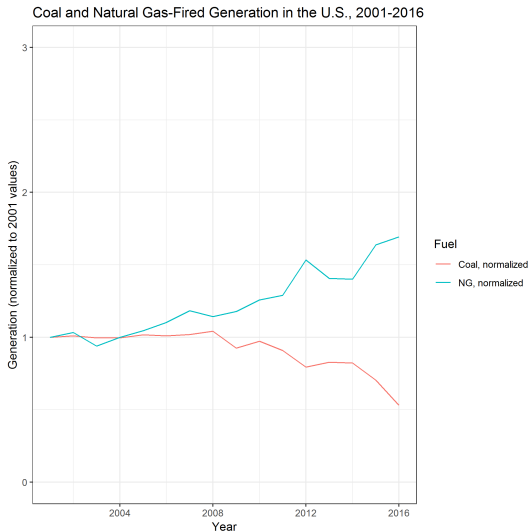


Figure 1: Coal and Natural Gas-fired Power Generation in the US, 2001-2016

Data Source: EIA 860/ 923

# Introduction

- Natural gas (NG) price has declined by 64% since 2016.
- Causes: recession, shale gas boom, hydraulic fracturing, horizontal drilling innovation
- US domestic NG production  $\uparrow$  44%
- NG increasingly being used for electricity generation
- Coal-reliant power plants  $\rightarrow$  switching from coal to NG use

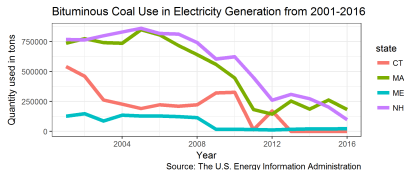
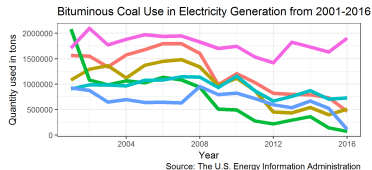


Figure 2

# Research Question

- Effects of power plants on housing prices (Davis 2011)
- Housing prices and environmental health risk (Currie et al. 2011)

This paper

How coal to natural gas fuel use transition of the power plants affect local housing market?

# Background

## Pollution and air quality/ Power plants externalities

- Pollution originating from power plants → Households value the externalities → Negative effect on nearby housing prices
- Natural gas use ↑ by the power plants → Pollution level ↓ → Less negative effect on housing prices

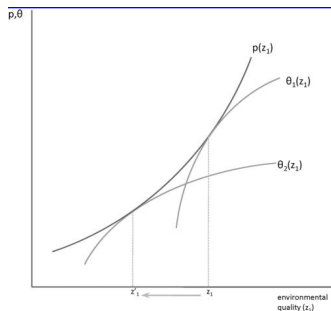


Figure 3: Hedonic Price Schedule and Environmental Quality

Source: Davis (2011)

# Paper Summary

## What we do

- Examine coal-NG power plant transition on housing price

## How we do

- Bin approach, distance from power plants

## What we find

- Fuel transition reflected on the effect on housing prices in the preliminary result

Related Work

# Motivation

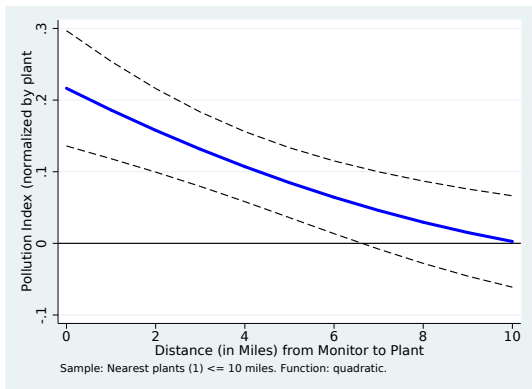


Figure 4: Pollution Gradient from Distance to Air Quality Monitors to Power Plants

Data Source: USEPA airquality

## Identification

Treatment Group: Properties with coal/ NG power plants within (0-5) km in year of sale

Treatment Variables

- Continuous/binary indicators of extent of coal/NG use within 0-5 km
- % change in coal/NG use within 0-5 km from prior year ( $t - 1$ ) to year of sale  $t$  (coal-switching proxy)

Control Group: Properties with coal/ NG power plants within (5-20) km in year of sale

Control Variables

- Continuous/binary indicators of extent of coal/NG use within 5-20 km
- % change in coal/NG use within 5-20 km from prior year ( $t - 1$ ) to year of sale  $t$  (coal-switching proxy)

Pseudo Diff-in-diff: Pre vs post spatial treatment and time variation.



# Model 1

$$\begin{aligned} \ln(\text{Property Price})_{ict} &= \alpha_0 \\ &+ \sum_{d \in B} \alpha_d (\text{Coal Powered Plants Binary Indicator})_{dit} \\ &+ \sum_{d \in B} \gamma_d (\% \text{ change in Coal use from } (t-1) \text{ to } t)_{dit} \\ &+ \sum_{d \in B} \delta_d (\text{NG Powered Plants Binary Indicator})_{dit} \\ &+ \sum_{d \in B} \kappa_d (\% \text{ change in NG use from } (t-1) \text{ to } t)_{dit} + \mu_{ic} + \nu_{ct} + \epsilon_{ict} \quad (1) \end{aligned}$$

Here,  $B = (0 - 5, 5 - 20)$ (distances in kilometers),

$i =$  (properties);  $c =$  (counties);  $t = 2003, 2004, \dots, 2016$ (years);

## Model 2

$$\begin{aligned} \ln(\text{Property Price})_{ict} &= \alpha_0 \\ &+ \sum_{d \in B} \beta_d (\text{Total Coal Use of Coal Powered Plants})_{dit} \\ &+ \sum_{d \in B} \gamma_d (\% \text{ change in Coal use from } (t-1) \text{ to } t)_{dit} \\ &+ \sum_{d \in B} \theta_d (\text{Total NG Use of NG Powered Plants})_{dit} \\ &+ \sum_{d \in B} \kappa_d (\% \text{ change in NG use from } (t-1) \text{ to } t)_{dit} + \mu_{ic} + \nu_{ct} + \epsilon_{ict} \quad (2) \end{aligned}$$

Here,  $B = (0 - 5, 5 - 20)$ (distances in kilometers),

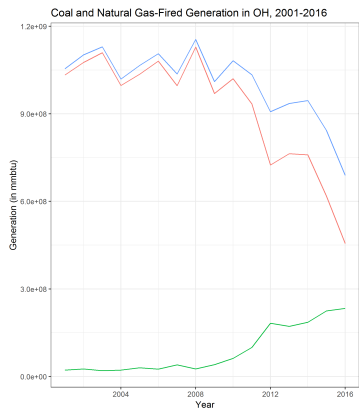
$i =$  (properties);  $c =$  (counties);  $t = 2003, 2004, \dots, 2016$ (years);

# Data

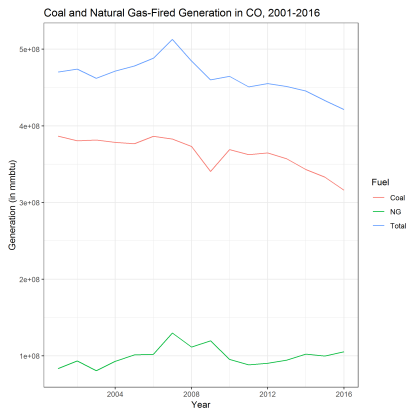
- Property price and property characteristics: ZTRAX database by Zillow
- Coal and natural gas use: EIA form 860, EIA form 923
- Property level annual panel data, 2003-2016
- Study sample: CO, OH; future expansion: WV, PA, NY
- Counties: CO(64), OH(88)

Summary Stat

# Motivation



(a) OH



(b) CO

Figure 5: Coal and Natural Gas-fired Electricity Generation, 2003-2016

# Results

**Table 1:** The effect of coal and natural gas powered electricity generation on housing prices in CO and OH

	CO		OH	
	Continuous	Binary	Continuous	Binary
Coal-fired generation in year of sale, 0-5 km	-3.11e-09 (3.73e-09)	-0.0911*** (0.0266)	7.33e-10 (7.74e-10)	-0.0206 (0.0239)
% change in coal-fired generation 0-5 km, pre vs. year of sale	0.00206 (0.0156)	-0.0344* (0.0187)	-7.93e-08 (1.01e-07)	-8.39e-08 (1.02e-07)
Coal-fired generation in year of sale, 5- 20km	-1.66e-09 (4.86e-10)	-0.000493 (0.0207)	1.47e-09*** (4.87e-10)	0.00393 (0.0222)
% change in coal-fired generation 5- 20km, pre vs. year of sale	0.0165 (0.0185)	-0.00832 (0.0202)	-1.14e-07 (7.42e-08)	-1.12e-07 (8.48e-08)
Natural gas-fired generation in year of sale, 0-5 km	5.12e-09 (3.15e-09)	-0.0522 (0.0313)	2.23e-09 (2.38e-09)	-0.0378** (0.0177)
% change in natural gas-fired generation in 0-5 km, pre vs. year of sale	3.91e-05 (0.000155)	2.57e-05 (0.000164)	1.04e-08 (6.73e-08)	-5.95e-09 (6.84e-08)
Natural gas-fired generation in year of sale, 5- 20km	1.73e-09 (1.69e-09)	-0.0283 (0.0236)	1.28e-09 (1.27e-09)	-0.0212 (0.0205)
% change in natural gas-fired generation 5-20km, pre vs. year of sale	0.000497 (0.000358)	8.88e-05 (0.000231)	-1.01e-08 (1.17e-08)	-1.25e-08 (1.17e-08)
# of observations	770,085	770,085	1,287,558	1,287,558
R-Squared	0.151	0.150	0.090	0.089

Notes: Dependent variable:  $\ln(\text{Housing Price})$ . Standard Errors (in parentheses) are clustered by counties. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . All regressions include property FE and year FE.

## Result Summary

- Increased coal use negatively affect housing prices both in (0-5) km and (5-20) km bin
- Increased natural gas use less adversely affect housing prices both in (0-5) km and (5-20) km bin

### Ongoing considerations

- Control for pollution abatement technology, example: Flue Gas Desulfurization
- Different treatment buffer (reference: Figure 3)
- Studies looking at wider buffer (Johnsen et al. 2017)
- Expand the study for NY, PA, WV

Questions/ comments?  
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## Related Work and Contribution

### Coal and air quality

- Yokoyama et al. 2000; Xu et al. 2017, Yang and Chou 2018

### Coal fired electricity generation health effects

- Fitzpatrick 2018, Jha and Muller 2017

### Natural gas and improvement in air quality

- Johnsen et al. (2017)

### Power plant effects on housing market

- Davis (2011)

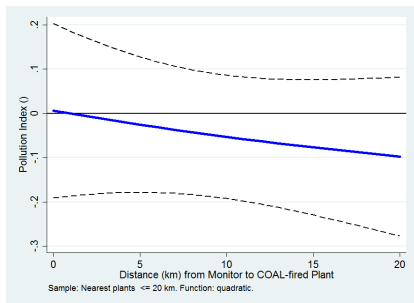
### Housing Price and Environmental Quality

- Currie, Davis, and Walker (2011)

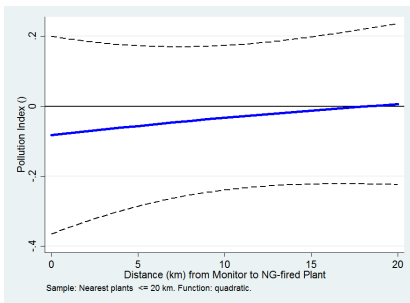
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(a) Coal fired-plants



(b) Natural Gas fired plants

Figure 6: Pollution Gradient from Distance to Air Quality Monitors to Power Plants

Data Source: USEPA airquality

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# Summary Statistics

Table 2: Summary statistics

	Colorado			Ohio		
	All obs.	Coal	NG	All obs.	Coal	NG
		0-5km > 0	0-5km > 0		0-5km > 0	0-5km > 0
Sales Price (\$)	311,513	279,450	297,194	158,203	161,666	161,015
% with Coal within 0-5km > 0	6.6			4.8		
% with NG within 0-5km > 0	15.4			9.1		
# of observations	875,851	57,816	135,019	1,287,558	61,729	116,669

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# Results

**Table 3:** The effect of coal and natural gas powered electricity generation on housing prices in Ohio

	0 - 5km treatment buffer					
	Coal		Natural Gas		Both	
	Continuous	Binary	Continuous	Binary	Continuous	Binary
Coal-fired generation in year of sale, treatment area	7.00E-10 (7.62e-10)	-0.0307 (0.0240)			7.33e-10 (7.74e-10)	-0.0206 (0.0239)
% change in coal-fired generation in treatment area, pre vs. year of sale	-7.84e-08 (1.00e-07)	-8.70e-08 (1.04e-07)			-7.93e-08 (1.01e-07)	-8.39e-08 (1.02e-07)
Coal-fired generation in year of sale, between treatment area and 20km	1.44e-09*** (4.86e-10)	-0.00120 (0.0207)			1.47e-09*** (4.87e-10)	0.00393 (0.0222)
% change in coal-fired generation between treatment area and 20km, pre vs. year of sale	-1.13e-07 (7.36e-08)	-1.12e-07 (8.64e-08)			-1.14e-07 (7.42e-08)	-1.12e-07 (8.48e-08)
Natural gas-fired generation in year of sale, treatment area			1.93e-09 (2.68e-09)	-0.0457** (0.0208)	2.23e-09 (2.38e-09)	-0.0378** (0.0177)
% change in natural gas-fired generation in treatment area, pre vs. year of sale			-2.28e-09 (6.76e-08)	-1.31e-08 (6.65e-08)	1.04e-08 (6.73e-08)	-5.95e-09 (6.84e-08)
Natural gas-fired generation in year of sale, between treatment area and 20km			8.60e-10 (1.36e-09)	-0.0196 (0.0199)	1.28e-09 (1.27e-09)	-0.0212 (0.0205)
% change in natural gas-fired generation between treatment area and 20km, pre vs. year of sale			-1.16e-08 (1.13e-08)	-1.23e-08 (1.12e-08)	-1.01e-08 (1.17e-08)	-1.25e-08 (1.17e-08)
# of observations	1,287,558	1,287,558	1,287,558	1,287,558	1,287,558	1,287,558
R-Squared	0.090	0.089	0.089	0.089	0.090	0.089

Notes: Dependent variable:  $\ln(\text{Housing Price})$ . Standard Errors (in parentheses) are clustered by counties. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . All regressions include property FE and year FE.

# Results

**Table 4:** The effect of coal and natural gas powered electricity generation on housing prices in Colorado

	0 - 5km treatment buffer					
	Coal		Natural Gas		Both	
	Continuous	Binary	Continuous	Binary	Continuous	Binary
Coal-fired generation in year of sale, treatment area	-4.15e-09 (3.26e-09)	-0.0893*** (0.0245)			-3.11e-09 (3.73e-09)	-0.0911*** (0.0266)
% change in coal-fired generation in treatment area, pre vs. year of sale		-0.00322 (0.0156)			0.00206 (0.0150)	-0.0344* (0.0180)
Coal-fired generation in year of sale, between treatment area and 20km	-1.66e-09 (9.94e-10)	-0.000493 (0.0139)			-1.35e-09 (9.96e-10)	-0.00363 (0.0143)
% change in coal-fired generation between treatment area and 20km, pre vs. year of sale		0.00671 (0.0185)			0.0165 (0.0228)	-0.00832 (0.0181)
Natural gas-fired generation in year of sale, treatment area			7.79e-09*** (1.87e-09)	-0.0508 (0.0304)	5.12e-09 (3.15e-09)	-0.0522 (0.0313)
% change in natural gas-fired generation in treatment area, pre vs. year of sale			4.76e-05 (0.000157)	2.77e-05 (0.000164)	3.91e-05 (0.000155)	2.57e-05 (0.000164)
Natural gas-fired generation in year of sale, between treatment area and 20km			2.87e-09* (1.61e-09)	-0.0265 (0.0263)	1.73e-09 (1.69e-09)	-0.0283 (0.0236)
% change in natural gas-fired generation between treatment area and 20km, pre vs. year of sale			0.000743 (0.000526)	0.000625 (0.000451)	0.000497 (0.000358)	8.88e-05 (0.000231)
# of observations	770,085	770,085	770,085	770,085	770,085	770,085
R-Squared	0.150	0.149	0.150	0.149	0.151	0.150

Notes: Dependent variable:  $\ln(\text{Housing Price})$ . Standard Errors (in parentheses) are clustered by counties. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . All regressions include property FE and year FE.

**Table 5:** The effect of coal and natural gas generation on housing prices in CO, only treatment group

	Coal		Natural Gas		Both	
	Continuous	Binary	Continuous	Binary	Continuous	Binary
Coal-fired generation in year of sale, 0-5 km buffer	-4.09e-09 (3.11e-09)	-0.0917*** (0.0245)			-3.38e-09 (3.58e-09)	-0.0938*** (0.0258)
% change in coal-fired generation in 0-5 km buffer, pre vs. year of sale	-0.00349 (0.0159)	-0.0327* (0.0182)			0.00271 (0.0160)	-0.0340* (0.0176)
Natural gas-fired generation in year of sale, 0-5 km buffer			7.39e-09*** (1.84e-09)	-0.0526* (0.0306)	4.63e-09 (3.03e-09)	-0.0541* (0.0313)
% change in natural gas-fired generation in 0-5 km buffer, pre vs. year of sale			4.19e-06*** (9.67e-07)	3.48e-06*** (1.10e-06)	4.28e-06*** (9.62e-07)	3.48e-06*** (1.10e-06)
# of observations	875,851	875,851	875,851	875,851	875,851	875,851
R-Squared	0.132	0.132	0.132	0.132	0.133	0.132

**Table 6:** The effect of coal and natural gas generation on housing prices in Ohio (observations in U.S. Census Bureau-defined places, Ohio, Only Treatment Group)

	Coal		Natural Gas		Both	
	Continuous	Binary	Continuous	Binary	Continuous	Binary
Coal-fired generation in year of sale, 0-5 km buffer	7.00E-10 (7.62e-10)	-0.0307 (0.0240)			7.33e-10 (7.74e-10)	-0.0206 (0.0239)
% change in coal-fired generation in 0-5 km buffer, pre vs. year of sale	-7.84e-08 (1.00e-07)	-8.70e-08 (1.04e-07)			-7.93e-08 (1.01e-07)	-8.39e-08 (1.02e-07)
Natural gas-fired generation in year of sale, 0-5 km buffer			1.93e-09 (2.68e-09)	-0.0457** (0.0208)	2.23e-09 (2.38e-09)	-0.0378** (0.0177)
% change in natural gas-fired generation in 0-5 km buffer, pre vs. year of sale			-2.28e-09 (6.76e-08)	-1.31e-08 (6.65e-08)	1.04e-08 (6.73e-08)	-5.95e-09 (6.84e-08)
# of observations	1,287,558	1,287,558	1,287,558	1,287,558	1,287,558	1,287,558
R-Squared	0.090	0.089	0.089	0.089	0.090	0.089

# Results

**Table 7:** The effect of coal and natural gas generation on housing prices in Colorado (observations in U.S. Census Bureau-defined places), CO towns/ Urban areas only, Treatment Group

	Coal		Natural Gas		Both	
	Continuous	Binary	Continuous	Binary	Continuous	Binary
Coal-fired generation in year of sale, 0-5 km buffer	-4.15e-09 (3.26e-09)	-0.0893*** (0.0245)			-3.11e-09 (3.73e-09)	-0.0911*** (0.0266)
% change in coal-fired generation in 0-5 km buffer, pre vs. year of sale	-0.00322 (0.0156)	-0.0330* (0.0187)			0.00206 (0.0150)	-0.0344* (0.0180)
Natural gas-fired generation in year of sale, 0-5 km buffer			7.79e-09*** (1.87e-09)	-0.0508 (0.0304)	5.12e-09 (3.15e-09)	-0.0522 (0.0313)
% change in natural gas-fired generation in 0-5 km buffer, pre vs. year of sale			4.76e-05 (0.000157)	2.77e-05 (0.000164)	3.91e-05 (0.000155)	2.57e-05 (0.000164)
# of observations	770,085	770,085	770,085	770,085	770,085	770,085
R-Squared	0.150	0.149	0.150	0.149	0.151	0.150