

ASSESSING THE IMPACT OF THE SHALE ENERGY BOOM ON OHIO LOCAL HOUSING MARKETS

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We thank the Ohio Housing Finance Administration for partial support in funding this research. The results presented here do not reflect the views of the OHFA.

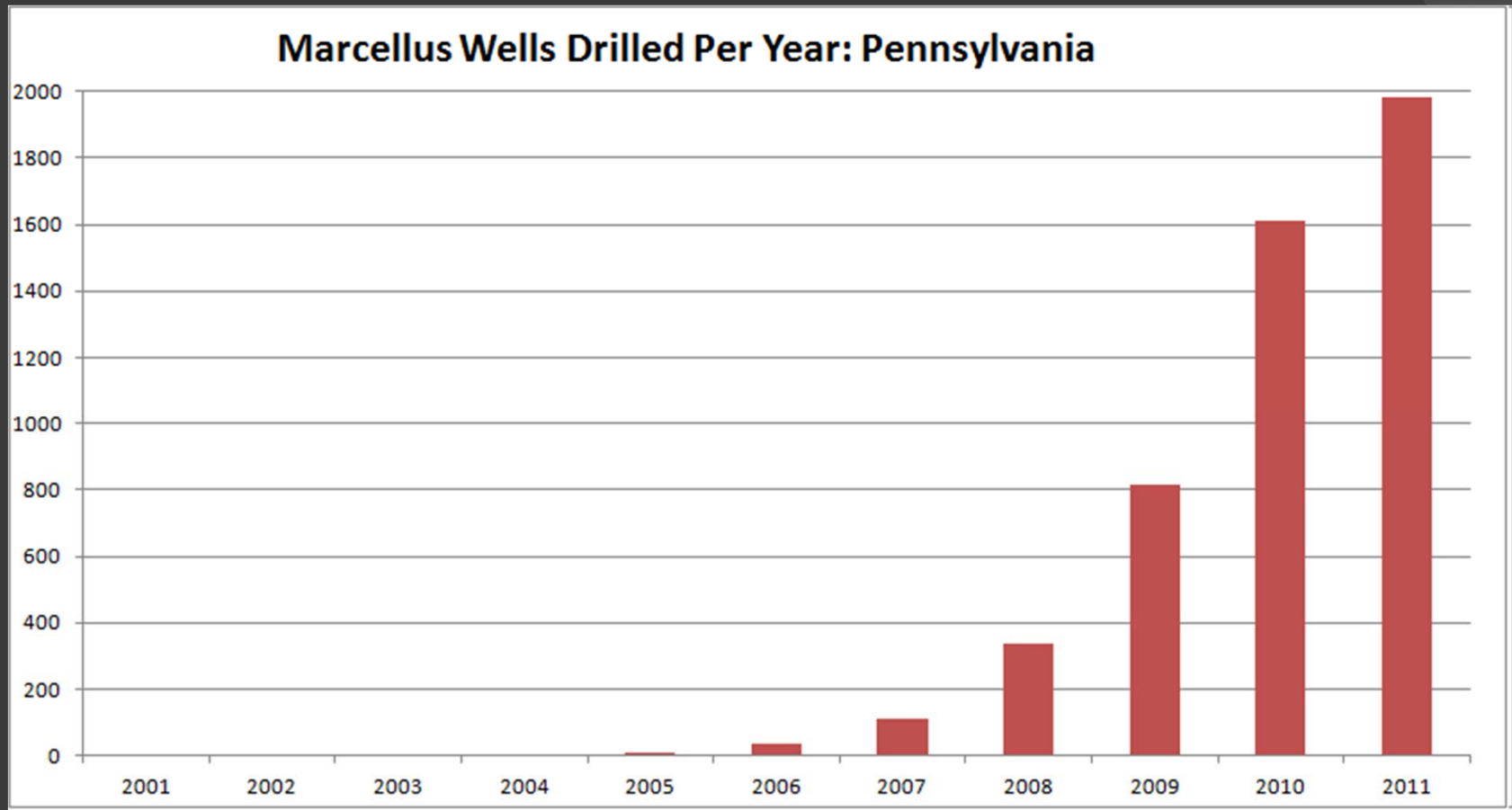
Outline

- I. Introduction and Background
- II. Conceptual Model/
Research Hypothesis
- III. Analysis Methodology
- IV. Results
- V. Recommendations

Introduction

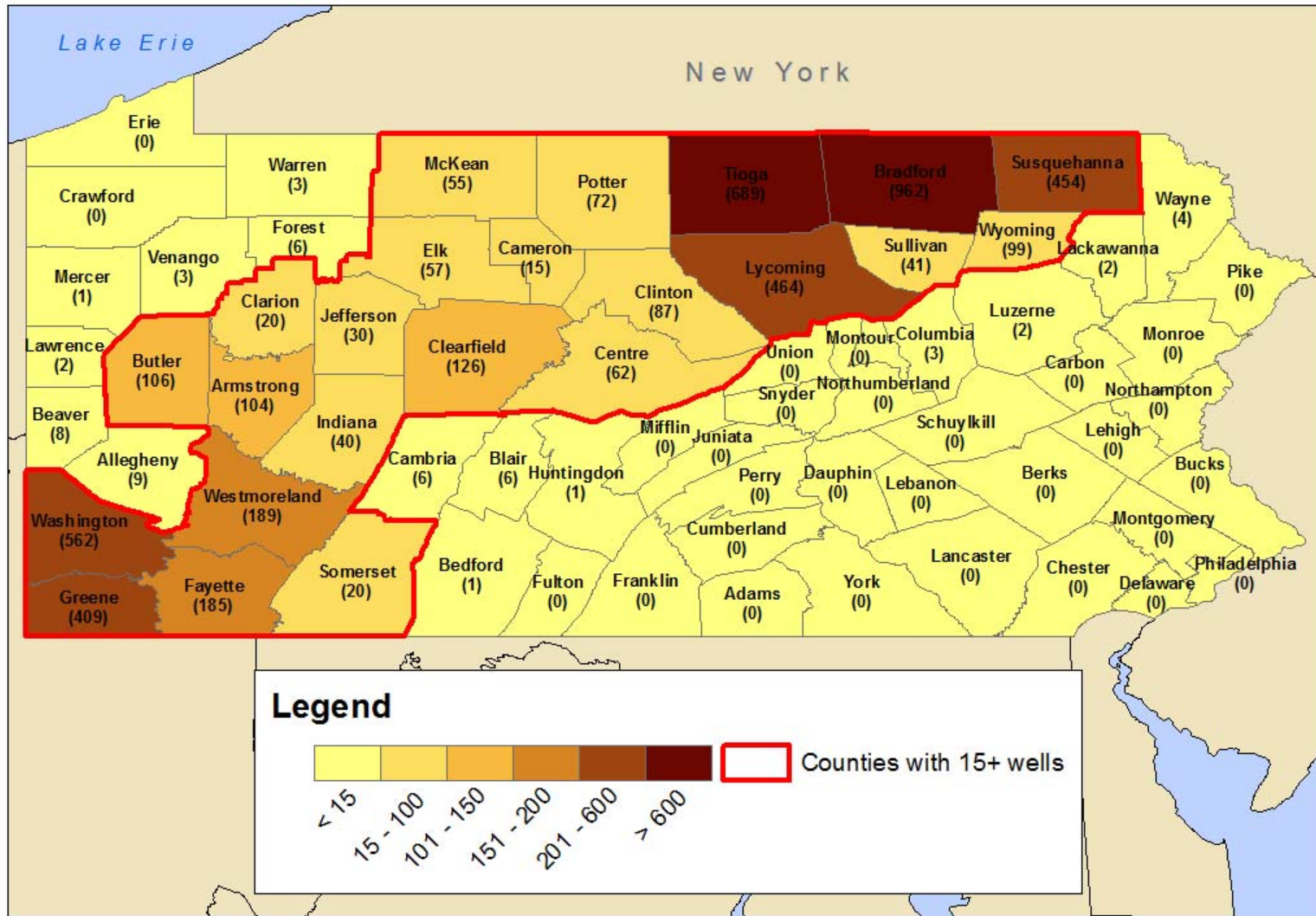
- This research attempts to quantify the potential effects of shale resource development in Pennsylvania on measures of housing market affordability and availability in order to anticipate the effect on Ohio's housing markets
- Ohio Housing Finance Agency provided partial support to help determine the potential effects of the shale gas boom in Ohio after media reports from Pennsylvania indicated severe local housing market shocks from the shale gas drilling region
- Partridge, Mark D., Michael Farren, Amanda Weinstein, and Mike Betz. "Assessing the Impact of Shale Energy Boom on Ohio Local Housing Markets." Final Report Submitted to the Ohio Housing Finance Agency. March 12, 2013.

The Shale Gas Boom



Source: Pennsylvania Department of Environmental Protection

Number of Shale Gas Wells per County as of 2011



Source: Pennsylvania Department of Environmental Protection

Stages of Shale Gas Development Relating to the Local Housing Market

Initial influx of energy industry workers

- Effects:

Increases county population and demand for temporary housing (mostly hotels if available)



Full-scale drilling operations begin

- Effects:

Further increases population and demand shifts to include medium-term rental housing



Mature well field management and maintenance

- Effects:

Demand shifts to include long-term residential housing for energy industry workers moving their families to the area in addition to potential new housing demand from the now-established local workforce

Measuring the Effect on the Local Housing Market

Initial influx of energy industry workers

- Metrics:

- 1) Population
- 2) Vacancy Rate
- 3) Fair Market Rent
- 4) Median Rent
- 5) Median Home Value



Full-scale drilling operations begin

- Metrics:

- 1) Population
- 2) Vacancy Rate
- 3) Fair Market Rent
- 4) Median Rent
- 5) Median Home Value



Mature well field management and maintenance

- Metrics:

- 1) Population
- 2) Residential Building Permits
- 3) Median Home Value

Data – Dependent Variables

<u>Annual Data</u> 1997-2011	
<u>Metric:</u>	<u>Source:</u>
Population	US Bureau of Economic Analysis
Fair Market Rent	US Department of Housing and Urban Development
Residential Building Permits	US Census Bureau

<u>Decennial Data</u> 2000 & 2007-2011	
<u>Metric:</u>	<u>Source:</u>
Vacancy Rate	US Decennial Census & American Community Survey 5-year Estimates
Median Rent	US Decennial Census & American Community Survey 5-year Estimates
Median Home Value	US Decennial Census & American Community Survey 5-year Estimates

Data – Explanatory Variables (1/2)

◎ Primary Explanatory Variables:

1) Shale development employment

- EMSI (Economic Modeling Specialists Intl.) data using the following NAICS codes:
 - 2111 - Oil and Gas Extraction
 - 2131 - Support Activities for Mining
 - 4862 - Pipeline Transportation of Natural Gas
 - 2371 - Utility System Construction
 - 5413 - Architectural, Engineering, and Related Services
 - 3331 - Agriculture, Construction, and Mining Machinery Manufacturing
 - 2389 - Other Specialty Trade Contractors

2) Number of shale gas wells drilled

- Available from PA and WV Dept. of Env. Protection

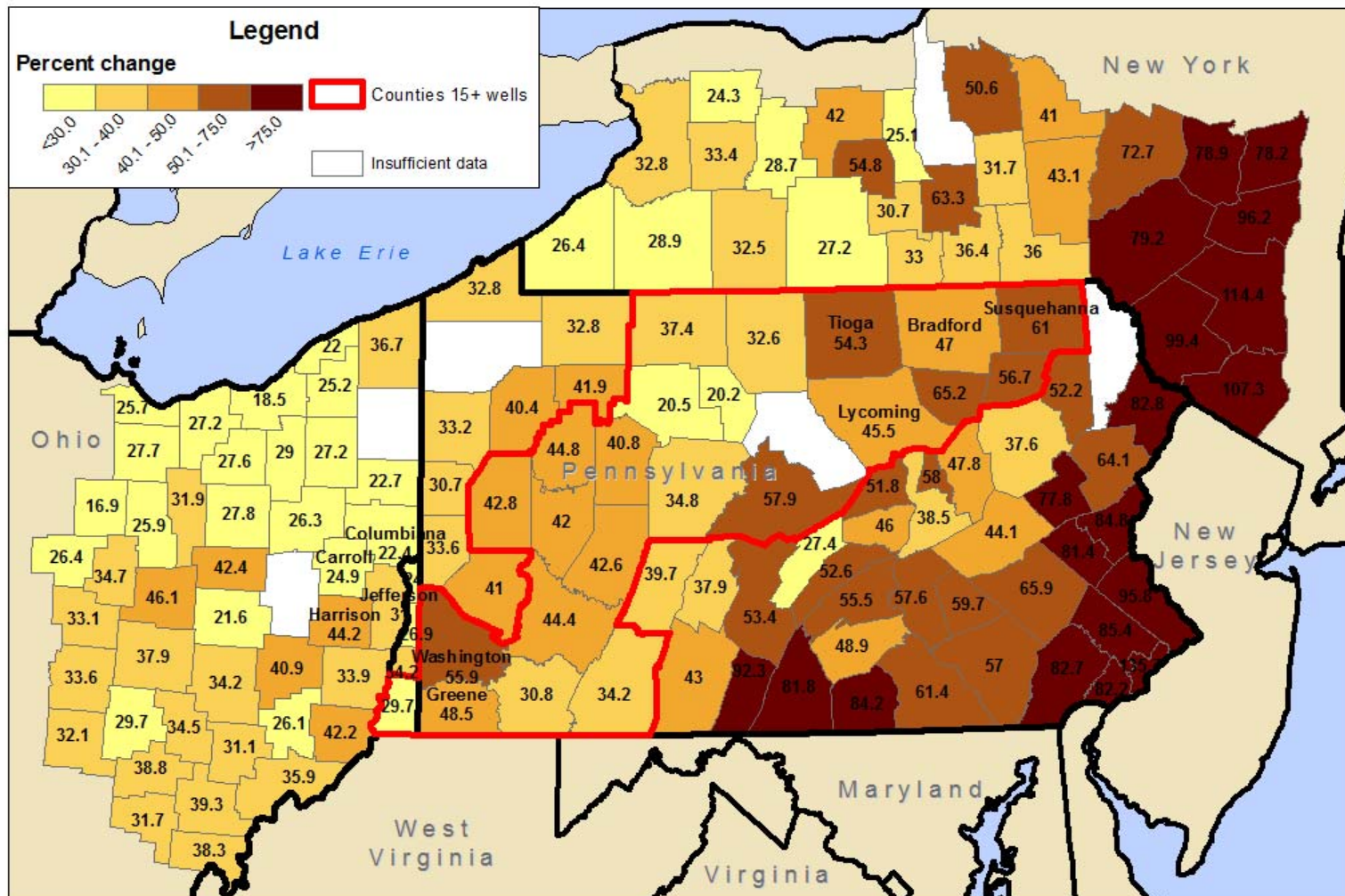
Data – Explanatory Variables (2/2)

○ Secondary Explanatory Variables:

- 1) Population (BEA)
- 2) Median per-capita personal income (BEA)
- 3) Poverty rate (US Census - SAIPE)
- 4) IndMix (EMSI)
 - Expected county employment growth rate given that the industries in the county grew at the national rate of growth.
 - Weighted by each industry's initial share of the county workforce
- 5) Controls included for the Appalachian region and Metropolitan Statistical Areas (ARC & US Census)

Analysis Region

Percent Change in Median Home Values 2000-2011



Analysis Methodology

- 1) Two-way fixed effects estimation
 - Annual data

- 2) Difference-in-Difference estimation
 - Annual data

- 3) First-difference estimation
 - Decennial data

Results Summary (1/3)

- 1) A 1% increase in shale development employment share is associated with a 0.5% increase in county population.
 - This would correspond to a 1.75% increase in Bradford County, PA (roughly 1,100 people).
- 2) The Fair Market Rent shows increases only in counties with the most intense drilling activity.
 - Bradford County, PA saw an increase of around 3.6% associated with the number of shale wells drilled.

Results Summary (2/3)

- 3) The number of single-unit residential building permits approved showed strong and consistent correlations across all specifications.
 - Each shale gas well drilled was associated with ~2.5 additional housing permits approved.
- 4) Vacancy rate, median rent and median home value (all of the decennial Census-based variables) generally showed poor results, most likely because of data problems.

Results Summary (3/3)

- 5) Data from Core Logic was used to obtain better results regarding home valuations.
- Unfortunately, the data provided was incomplete and did not cover all of the shale drilling counties.
 - The results suggest that 1% increase in shale development job share is associated with about a 0.2-0.4% increase in median home resale values. For comparison, that would suggest Bradford County's median home prices are about 0.7%-1.4% higher due to the 2007-2011 energy boom.

Conclusions

- Shale resource development during the natural gas boom did have statistically significant effects on local housing markets, but the magnitude of those effects appears to be relatively mild
- Issues with the available data may cloud fully accurate analysis of the effects, but this also is an indication that the effects have not been so enormous or long-lasting that they would resist such occlusion.

Forecasting a Shale Energy Boom

- ◎ Oilfield Service Companies
 - RigData
 - Baker Hughes, Inc.
- ◎ Hotel Data Analysis
 - Smith Travel Research (STR)

THANK YOU

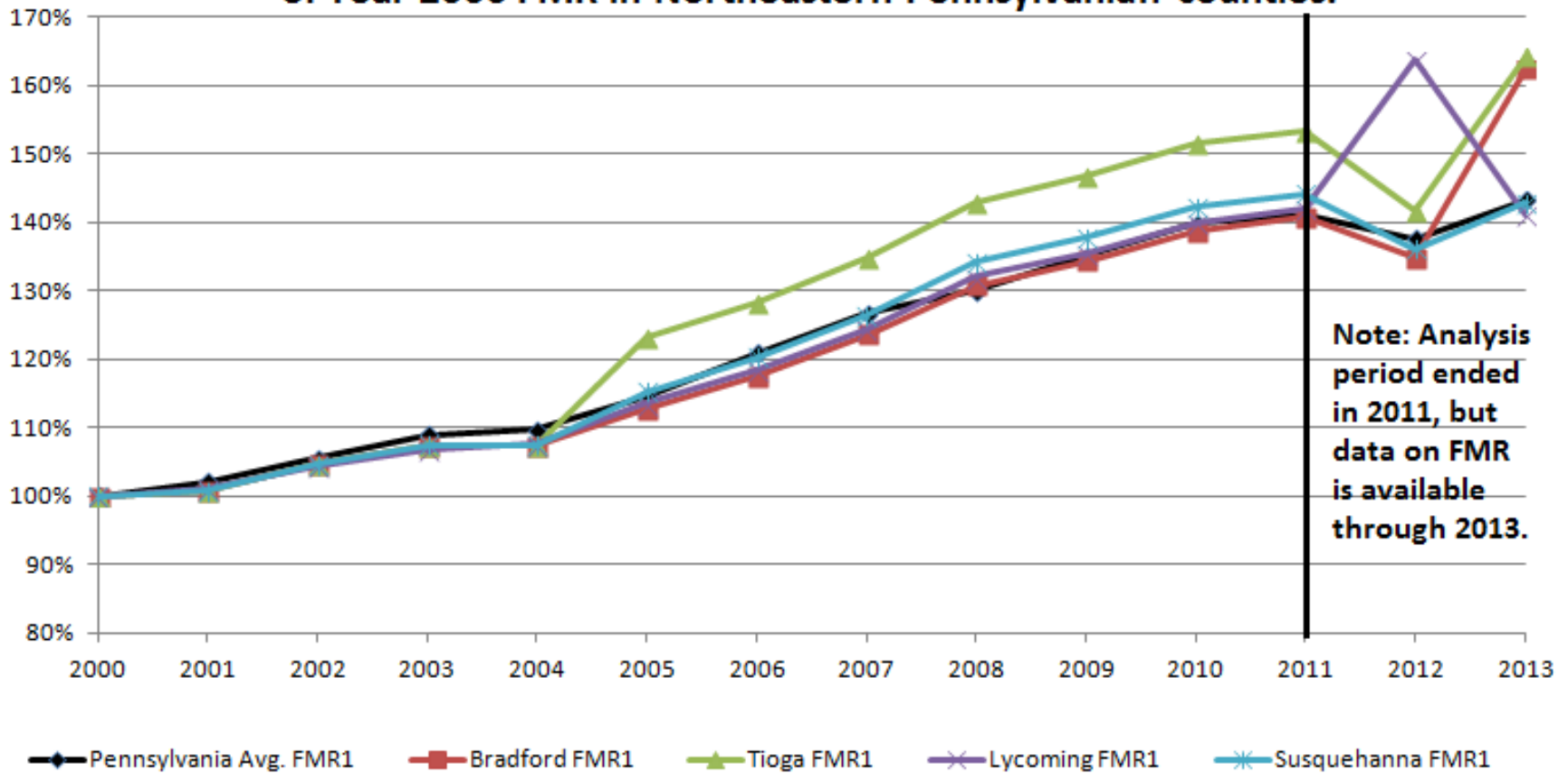
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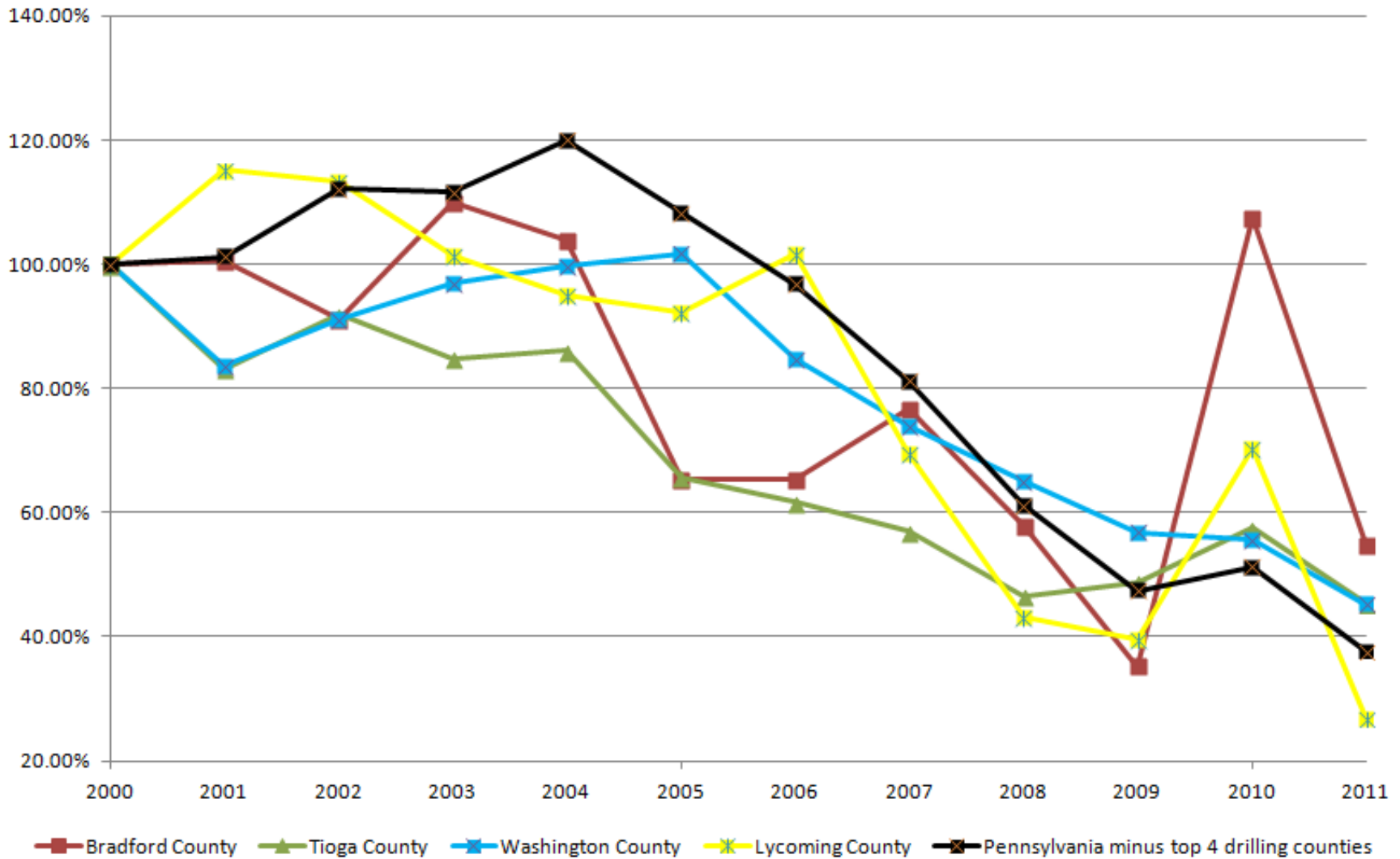
APPENDICES

Fair Market Rent (1 bedroom) 2000-2013 as a proportion of Year 2000 FMR in Northeastern Pennsylvanian counties.



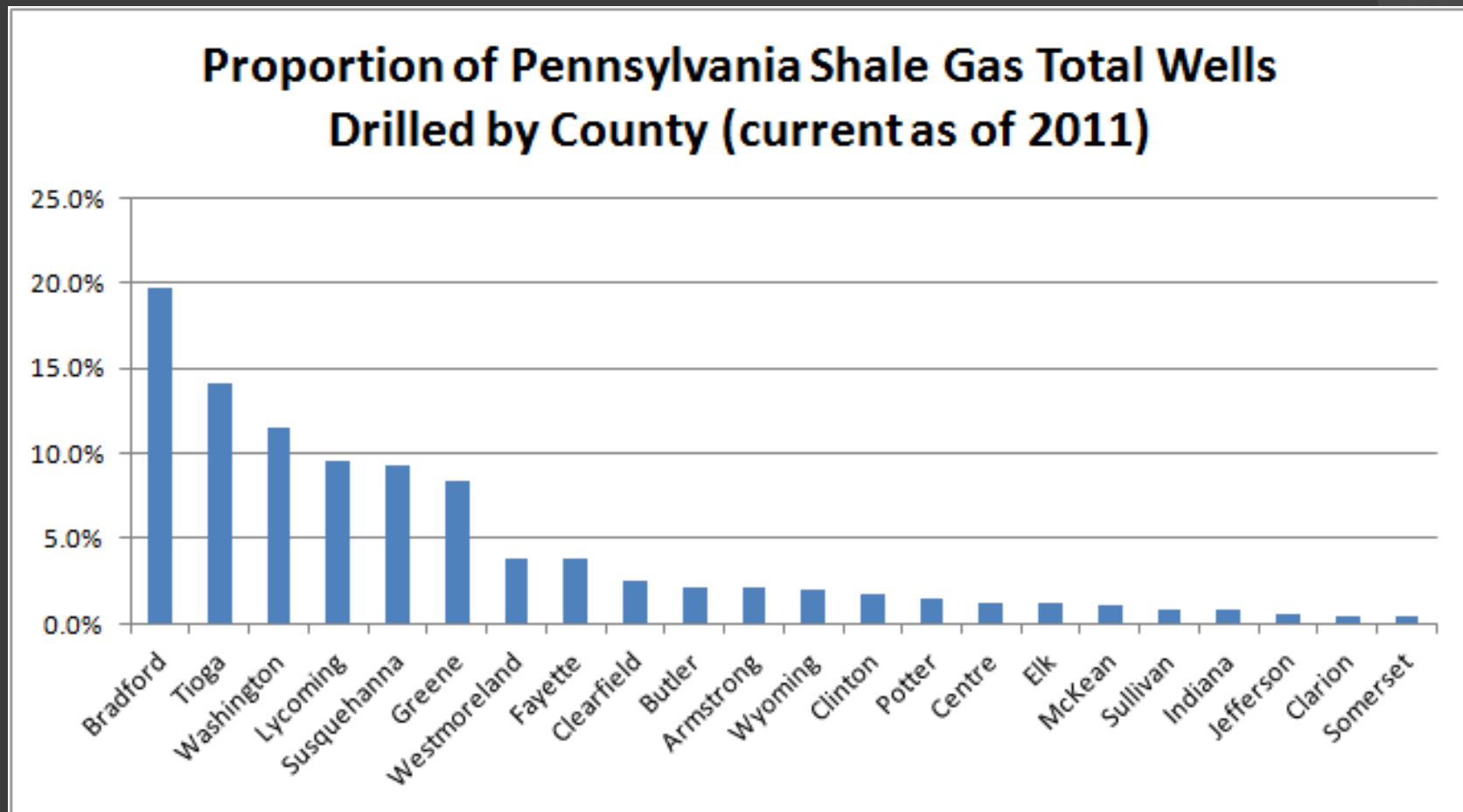
Source: US Dept. of Housing and Urban Development

Yearly Proportion of Residential 1-Unit Bldg. Permits Issued Relative to the Number of Permits Issued in the Year 2000 in the Top Four Shale Drilling Counties



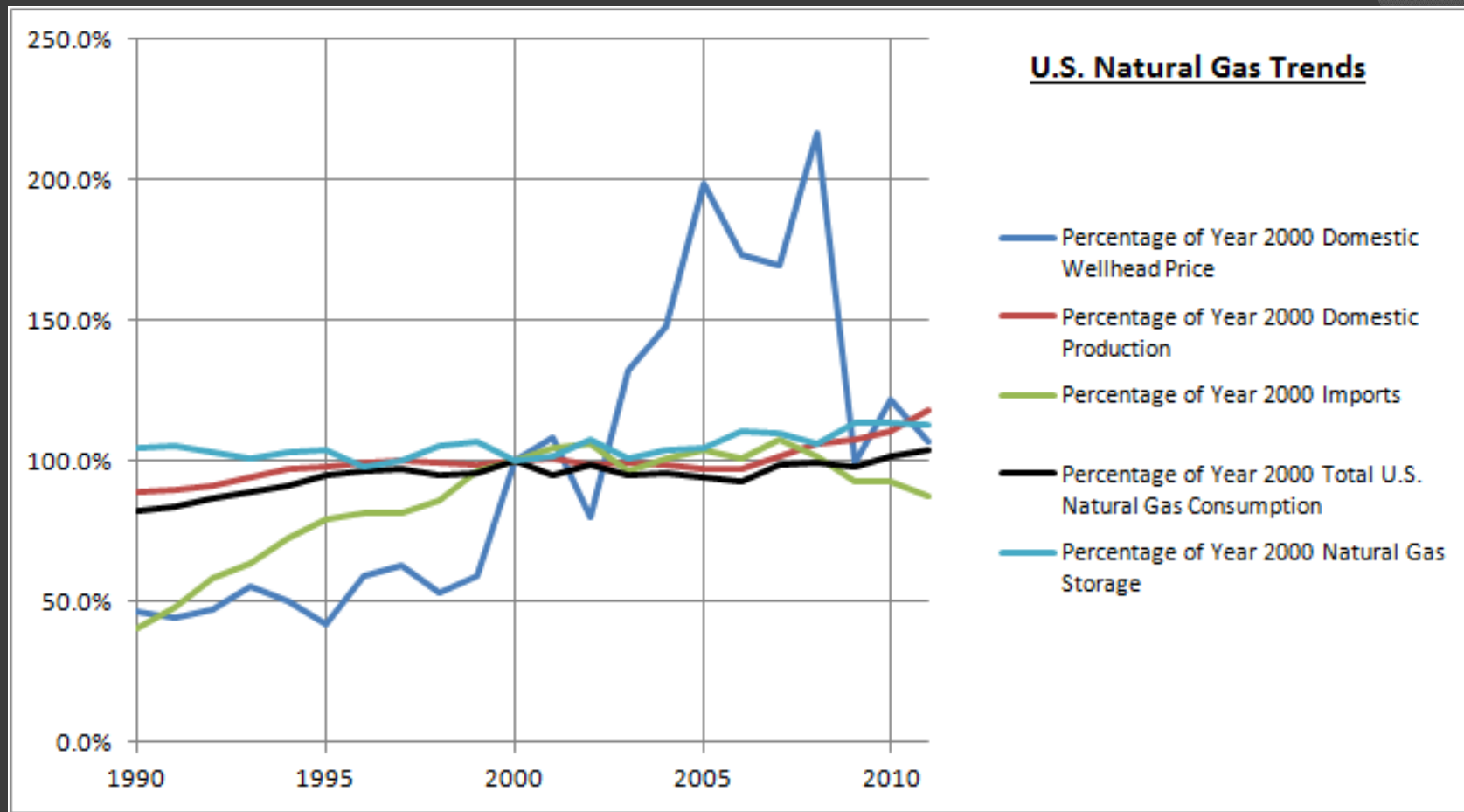
Source: US Census Bureau

The Shale Gas Boom



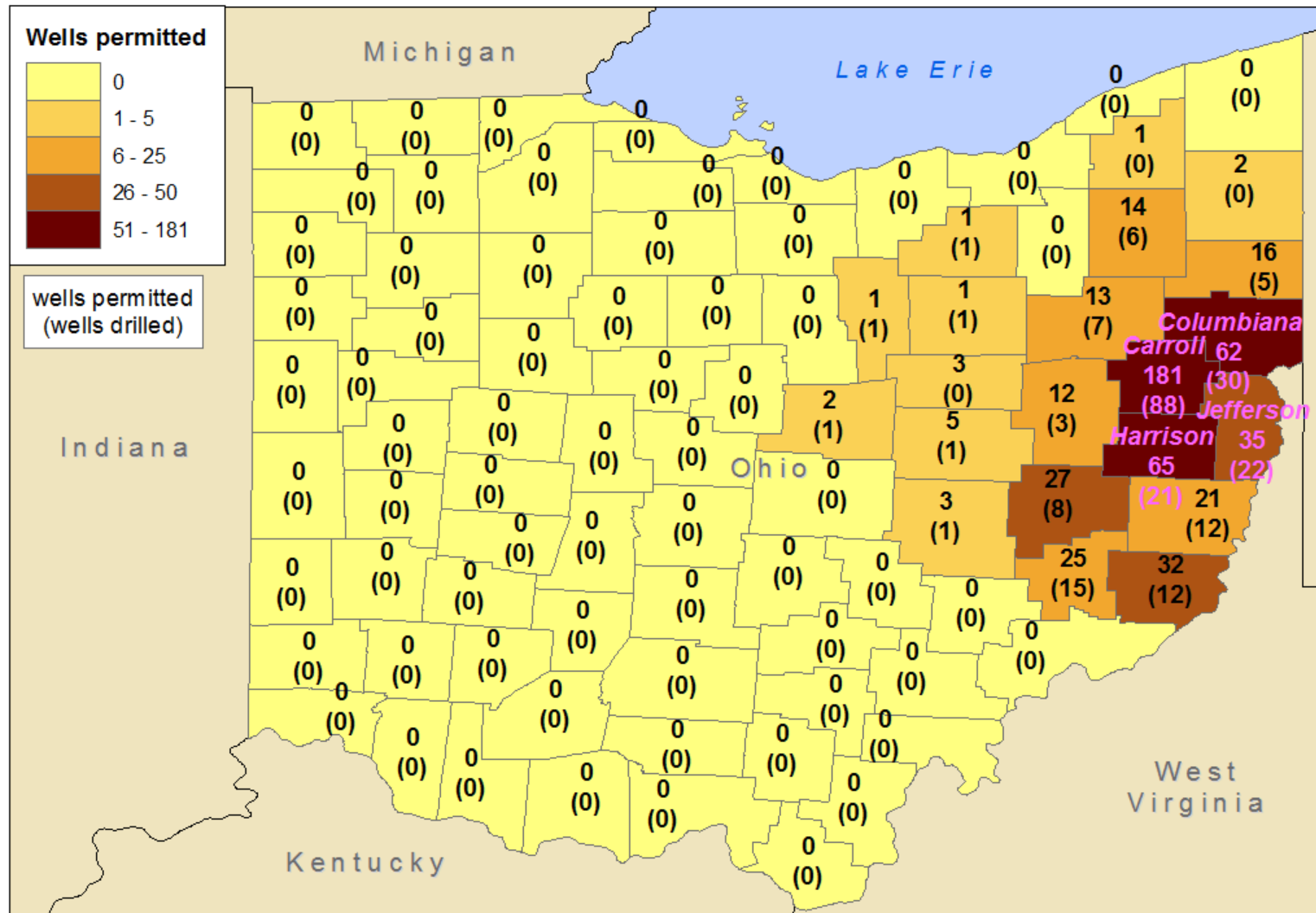
Source: Pennsylvania Department of Environmental Protection

The Shale Gas Boom



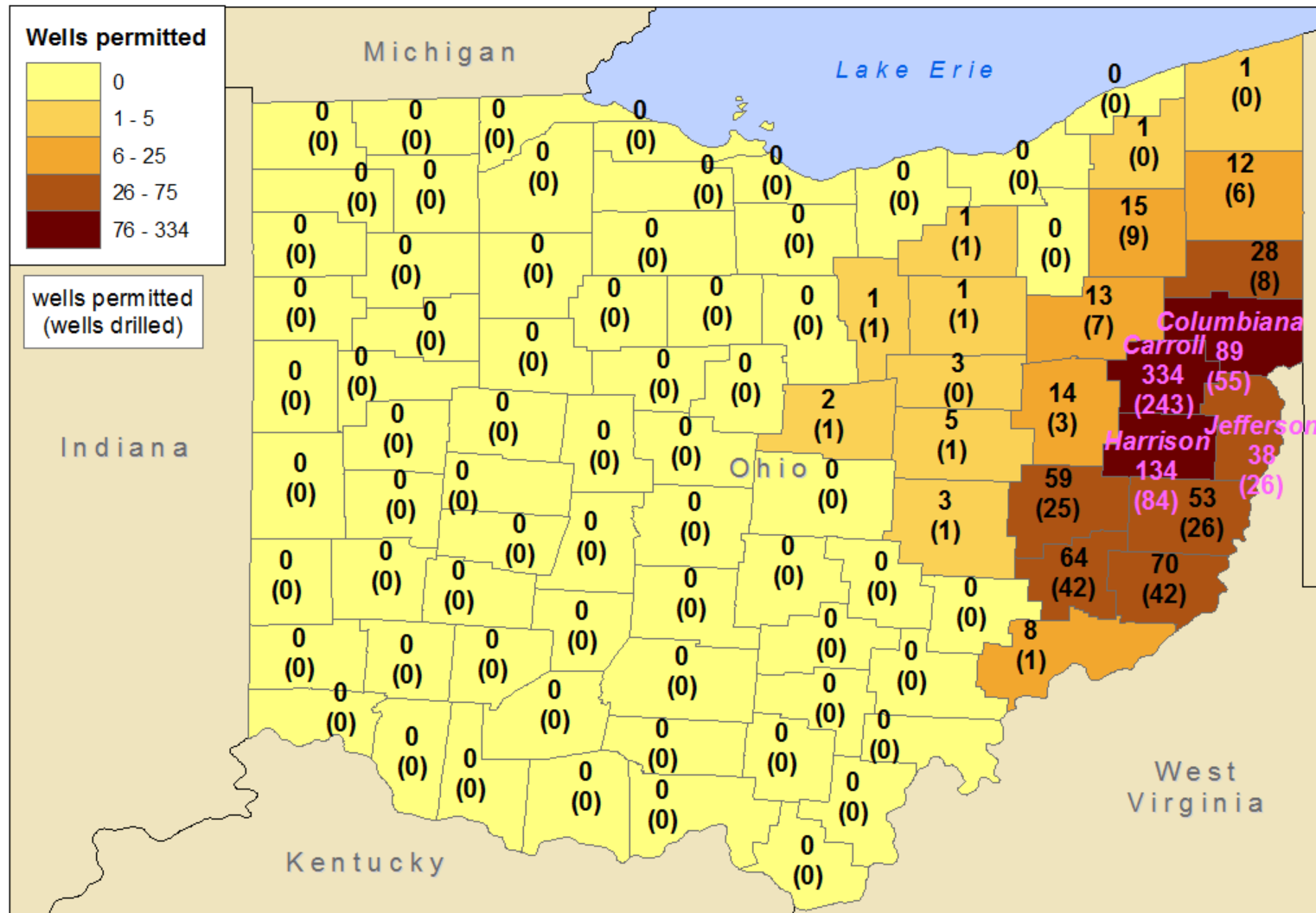
Source: U.S. Energy Information Administration

Number of Shale Gas Wells Permitted (Drilled) per County as of Jan-26-2013



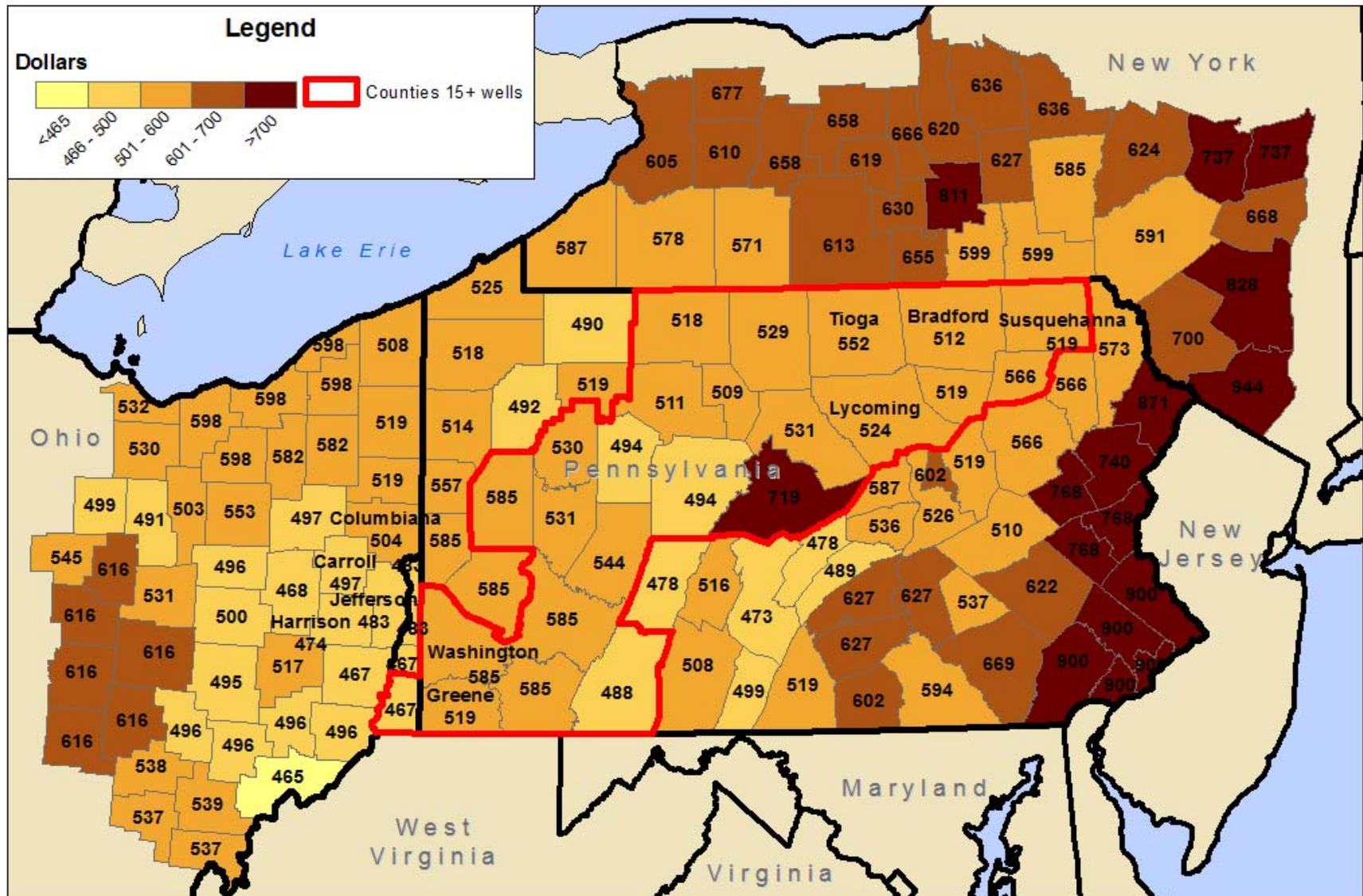
Source: Ohio Department of Natural Resources – Division of Oil & Gas Resources

Number of Shale Gas Wells Permitted (Drilled) per County as of Oct-5-2013



Source: Ohio Department of Natural Resources – Division of Oil & Gas Resources

1-Bedroom Fair Market Rent 2011



Source: US Dept. of Housing and Urban Development

Specification Variations

- ⦿ Each model is analyzed using the dependent and explanatory variables in levels, logs and arc elasticity
 - Variables which are already in percentage format are not altered (ie: poverty rate & expected employment growth)
 - The shale wells drilled variable is never transformed; the logarithm of variables equal to zero is re-coded to zero
- ⦿ Each model uses the primary explanatory variables in quadratic form to allow for nonlinear effects

Difference-in-Difference Format

DiD: $FMR_{DiD} = \{FMR_{2011} - FMR_{2007}\} - \{FMR_{2007} - FMR_{2003}\}$

$$FMR_{DiDlog} = \{\log(FMR_{2011}) - \log(FMR_{2007})\} - \{\log(FMR_{2007}) - \log(FMR_{2003})\}$$

$$FMR_{DiD\% \Delta} = \{\% \Delta FMR_{2007-2011}\} - \{\% \Delta FMR_{2003-2007}\}$$

where,

$$\% \Delta FMR_{2007-2011} = \{FMR_{2011} - FMR_{2007}\} / FMR_{2007} * 100\%$$

First-difference Format

Differenced: $\text{MedianRent}_{\text{Diff}} = \text{MedianRent}_{2011} - \text{MedianRent}_{2000}$

Diff_{log}: $\text{MedianRent}_{\text{logDiff}} = \log(\text{MedianRent}_{2011}) - \log(\text{MedianRent}_{2000})$

Diff_{%Δ}: $\text{MedianRent}_{\%Δ\text{Diff}} = \%Δ\text{MedianRent}_{2000-2011}$

where,

$$\%Δ\text{MedianRent}_{2000-2011} = \{\text{MedianRent}_{2011} - \text{MedianRent}_{2000}\} / \text{MedianRent}_{2000} * 100\%$$

Two-way Fixed Effects Analysis

$$X = \alpha + \beta_1 * \eta + \beta_2 * \eta^2 + \delta * \Phi + \rho * \Lambda + \tau * \Theta + \sigma * \Omega + \varepsilon$$

- X : *The measure of housing availability or affordability under consideration (ie: population, Fair Market Rent, or residential building permits approved).*
- η, η^2 : *The shale development metric of interest (ie: the number of shale wells drilled or jobs associated with shale development).*
- Φ : *A set of additional explanatory variables controlling for the effects of population, median per-capita income, percent of the population in poverty, and expected employment growth based on industry composition.*
- Λ : *A set of dummy variables controlling for whether the county is in a Metropolitan Statistical Area or is part of the Appalachian region.*
- Θ : *A set of dummy variables controlling for time fixed effects.*
- Ω : *A set of dummy variables controlling for county-specific fixed effects.*
- ε : *The regression error term.*

Difference-in-Difference Analysis

$$X = \alpha + \beta_1 * \eta + \beta_2 * \eta^2 + \delta * \Phi + \rho * \Lambda + \gamma * \Psi + \varepsilon$$

- X : *The DiD, DiD_{log}, or DiD_{%Δ} measure of housing availability or affordability under consideration (ie: population, Fair Market Rent, or residential building permits approved).*
- η, η^2 : *The DiD, DiD_{log}, or DiD_{%Δ} in shale development-related employment. We only considered shale wells drilled during 2007-2011 for the difference-in-difference analyses so this metric is kept in level form rather than using its log or percent change for the DiD_{log} and DiD_{%Δ} regressions.*
- Φ : *A set of additional explanatory variables controlling for the differenced effects of population, median per-capita income, poverty and expected employment growth based on the county's initial industry composition.*
- Λ : *A set of dummy variables controlling for whether the county is in a Metropolitan Statistical Area or is part of the Appalachian region.*
- Ψ : *A set of explanatory variables controlling for initial values in the year 2000 (logged values of the dependent variable, population, and median per-capita income, as well as the percent of population in poverty and expected employment growth).*
- ε : *The regression error term.*

First-Difference Analysis

$$X = \alpha + \beta_1 * \eta + \beta_2 * \eta^2 + \delta * \Phi + \rho * \Lambda + \gamma * \Psi + \varepsilon$$

- X : *The differenced, $Diff_{\log}$, or $Diff_{\% \Delta}$ measure of housing availability or affordability under consideration (ie: Median Rent, Median Home Value or Vacancy Rate).*
- η, η^2 : *The difference, $Diff_{\log}$, or $Diff_{\% \Delta}$ in shale development-related employment between 2006-2011. We only considered shale wells drilled during 2007-2011 for the difference analyses so this metric is kept in level form rather than using its log or percent change for the $Diff_{\log}$ and $Diff_{\% \Delta}$ regressions.*
- Φ : *A set of additional explanatory variables controlling for the differenced effects of population, median per-capita income, poverty and expected economic growth on the housing measure studied.*
- Λ : *A set of dummy variables controlling for whether the county is in a Metropolitan Statistical Area or is part of the Appalachian region.*
- Ψ : *A set of explanatory variables controlling for initial values in the year 2000 (logged values of the population, median per-capita income, median rent and median home value, as well as the percent of population in poverty, the expected economic growth and the vacancy rate).*
- ε : *The regression error term.*

Difference-in-Difference Results

Table 14: Difference-in-Difference Regression; Shale Development Employment (Percent Change)

<i>Explanatory Variables</i> ¹	Difference in Percent Increase in Population	Difference in Percent Increase in FMR (0 Bedrooms)	Difference in Percent Increase in FMR (1 Bedrooms)	Difference in Percent Increase in FMR (2 Bedrooms)	Difference in Percent Increase in FMR (3 Bedrooms)	Difference in Percent Increase in FMR (4 Bedrooms)
Difference in Percent Increase in Shale Dev. Empl.	.497** (.221)	-1.58 (1)	.199 (.725)	.358 (.523)	.418 (.645)	.636 (.943)
Difference in Percent Increase in Shale Dev. Empl. Squared	6.4e-03 (.011)	-8.3e-03 (.062)	.03 (.04)	.041 (.031)	.051 (.035)	.041 (.05)
R-squared	0.395	0.167	0.176	0.222	0.293	0.301
Adjusted R-squared	0.345	0.084	0.093	0.144	0.222	0.231
F	8.972	4.941	2.426	3.366	5.693	6.591
Observations	144	144	144	144	144	144

Table 15: Difference-in-Difference Regression; Shale Wells Drilled (Percent Change)

<i>Explanatory Variables</i> ¹	Difference in Percent Increase in Population	Difference in Percent Increase in FMR (0 Bedrooms)	Difference in Percent Increase in FMR (1 Bedrooms)	Difference in Percent Increase in FMR (2 Bedrooms)	Difference in Percent Increase in FMR (3 Bedrooms)	Difference in Percent Increase in FMR (4 Bedrooms)
Shale Wells Drilled 2007-2011	1.5e-03 (5.2e-03)	-.112*** (.037)	-.067** (.028)	-.065** (.027)	-.067** (.031)	-.043 (.036)
Shale Wells Drilled 2007-2011 Squared	2.7e-06 (5.8e-06)	1.4e-04*** (3.8e-05)	7.1e-05** (3.0e-05)	7.4e-05** (3.0e-05)	7.8e-05** (3.3e-05)	4.1e-05 (4.0e-05)
R-squared	0.350	0.226	0.237	0.279	0.340	0.322
Adjusted R-squared	0.296	0.149	0.161	0.206	0.274	0.254
F	4.253	4.613	2.963	3.935	6.550	6.885
Observations	144	144	144	144	144	144

Notes: Each column denotes a single regression. Each value listed denotes the coefficient estimate for the explanatory variable at the left for the dependent variable listed above. Robust standard errors of coefficient estimates are shown in parentheses. We also control for the effects of each county's population, median per-capita income, poverty rate, and expected employment growth based the county's industry composition. We include dummy variables to control for urbanization if the county is part of a MSA (Metropolitan Statistical Area) and geographical/cultural effects if it is part of the Appalachian region. We use the logged Year 2000 values of population, median per-capita income and the dependent variable and the Year 2000 values of poverty rate and expected employment growth to control for initial levels.

* - Denotes statistical significance of 10% or better. (p-value < 0.10); ** - Denotes statistical significance of 5% or better. (p-value < 0.05); *** - Denotes statistical significance of 1% or better. (p-value < 0.01)

¹ - Shale Dev. Empl. denotes NAICS (North American Industry Classification System) industry codes which are connected with shale development employment. The specific NAICS codes we utilized to capture shale development employment effects are: 2111-Oil and Gas Extraction; 2131-Support Activities for Mining; 5413 -Architectural, Engineering, and Related Services; 2389-Other Specialty Trade Contractors; 3331-Agriculture, Construction, and Mining Machinery Manufacturing; 4862-Pipeline Transportation of Natural Gas; 2371-Utility System Construction

Two-Way Fixed Effects Results

Table 1: Two-Way Fixed Effects Regression; Shale Development Employment (Levels)

<i>Explanatory Variables</i> ¹	Res. Bldg. Permits (1 Units)	Res. Bldg. Permits (2 Units)	Res. Bldg. Permits (3-4 Units)	Res. Bldg. Permits (5+ Units)
Shale Dev. Empl.	.1331 (.0805)	-5.3e-04 (.0023)	.0034 (.0033)	.0048 (.0038)
Shale Dev. Empl. Squared	1.1e-06 (8.2e-06)	5.7e-08 (8.8e-08)	-2.1e-08 (2.3e-07)	-7.9e-08 (3.5e-07)
R-squared	0.382	0.040	0.118	0.075
Adjusted R-squared	0.376	0.031	0.109	0.067
F	12.77	3.360	3.068	3.895
Observations	2160	2160	2160	2160

Table 2: Two-Way Fixed Effects Regression; Shale Wells Drilled (Levels)

<i>Explanatory Variables</i> ¹	Res. Bldg. Permits (1 Units)	Res. Bldg. Permits (2 Units)	Res. Bldg. Permits (3-4 Units)	Res. Bldg. Permits (5+ Units)
Shale Wells Drilled	2.529*** (.956)	.0239 (.0296)	.0073 (.0204)	.0085 (.026)
Shale Wells Drilled Squared	-.0057** (.0027)	-5.7e-05 (7.9e-05)	-1.5e-05 (5.3e-05)	-1.4e-05 (6.4e-05)
R-squared	0.359	0.039	0.104	0.066
Adjusted R-squared	0.353	0.030	0.096	0.057
F	10.52	3.381	2.742	3.382
Observations	2160	2160	2160	2160

Table 3: Two-Way Fixed Effects Regression; Prev. Year Shale Wells Drilled (Levels)

<i>Explanatory Variables</i> ¹	Res. Bldg. Permits (1 Units)	Res. Bldg. Permits (2 Units)	Res. Bldg. Permits (3-4 Units)	Res. Bldg. Permits (5+ Units)
Prev. Year Shale Wells Drilled	2.728** (1.119)	.0185 (.0281)	.0032 (.0232)	-.0021 (.0372)
Prev. Year Shale Wells Drilled Squared	-.0062** (.0031)	-4.6e-05 (7.5e-05)	-8.9e-07 (6.2e-05)	1.4e-05 (9.5e-05)
R-squared	0.384	0.033	0.093	0.090
Adjusted R-squared	0.378	0.024	0.085	0.081
F	11.49	3.148	2.827	3.489
Observations	2016	2016	2016	2016

Notes: Each column denotes a single regression. Each value listed denotes the coefficient estimate for the explanatory variable at the left for the dependent variable listed above. Robust standard errors of coefficient estimates are shown in parentheses. We also control for the effects of each county's population, median per-capita income, poverty rate, and expected employment growth based on the county's industry composition. We include dummy variables to control for urbanization if the county is part of a MSA (Metropolitan Statistical Area) and geographical/cultural effects if it is part of the Appalachian region.

* - Denotes statistical significance of 10% or better. (p-value < 0.10); ** - Denotes statistical significance of 5% or better. (p-value < 0.05); *** - Denotes statistical significance of 1% or better. (p-value < 0.01)

¹ - Shale Dev. Empl. denotes NAICS (North American Industry Classification System) industry codes which are connected with shale development employment. The specific NAICS codes we utilized to capture shale development employment effects are: 2111-Oil and Gas Extraction; 2131-Support Activities for Mining; 5413 -Architectural, Engineering, and Related Services; 2389-Other Specialty Trade Contractors; 3331-Agriculture, Construction, and Mining Machinery Manufacturing; 4862-Pipeline Transportation of Natural Gas; 2371-Utility System Construction

Analysis Region

- Criteria for inclusion in the sample:
 - 1) County in PA, NY, OH or WV
 - 2) Overlying either the Marcellus Shale, Utica Shale, or both
 - 3) Defined to be a member of the Northern Appalachian Region if the county is in WV
- Results: All of PA, eastern OH, southern NY and the northern panhandle of WV are included