Resource and Energy Economics 46 (2016) 1–22

Contents lists available at ScienceDirect

Resource and Energy Economics

journal homepage: www.elsevier.com/locate/ree

The cost of unconventional gas extraction: A hedonic analysis☆

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ARTICLE INFO

Article history:
Received 7 October 2014
Received in revised form 4 July 2016
Accepted 17 July 2016
Available online 21 July 2016

JEL classification:
Q30
Q40
Q51

Keywords:
Unconventional gas extraction
Hedonic analysis
Marcellus Shale
Environmental costs

ABSTRACT

We focus on identification and estimation of potentially negative environmental impacts of unconventional natural gas extraction on property values in the United States and advance previous research by contributing new data and new identification strategies for isolating these potential impacts. Our study area consists of two counties in Pennsylvania that are home to large amounts of unconventional natural gas extraction but are otherwise isolated from other resource extraction industries or large urban areas. We deploy parametric, semi-parametric, and matching hedonic regression models that include recent quasi-experimental methods and, in contrast to previous research and much popular intuition, we fail to find robust significance that negative environmental externalities of natural gas extraction are manifested in nearby property values. While there may be plausible risks associated with unconventional natural gas extraction, we do not find consistent evidence to suggest that these risks significantly affect nearby property values.

1. Introduction

Economists have recently begun to show interest in measuring the environmental costs associated with unconventional natural gas production in the United States (e.g., Gopalakrishnan and Klaiber, 2014; Muehlenbachs et al., 2012, 2015; Boslett et al., 2015), no doubt in response to the rapid expansion of natural gas exploration and extraction in the Marcellus Shale formation in the northeastern part of the country.[1] While the potential environmental costs of unconventional gas extraction are widely known and documented – e.g., groundwater contamination (Jackson et al., 2013), air pollution (Litovitz et al., 2013), and forest fragmentation (Drohan et al., 2012) – only recently have economists begun to provide estimates of

☆ Michaela Jellicoe provided excellent research assistance. We are grateful to the Bradford and Lycoming County assessor offices for providing detailed property sale records. We thank Tim Beatty, Raymond J.G.M. Florax, Benjamin Gramig, Martin Heintzleman, Daniel Henderson, Farzad Taheripour, Sophia Villas-Boas, and participants at the 2014 World Congress of Environmental and Resource Economists, 2014 4th Annual Asian Meetings of the International Association of Energy Economics, the 2015 American Enterprise Institute Emerging Scholars Workshop, the 2015 Meetings of the European Association of Environmental and Resource Economics, the University of Alabama, and the Purdue University SHaPE brownbag for helpful feedback. This research was supported in part by computational resources provided by Information Technology at Purdue – Rosen Center for Advanced Computing, Purdue University, West Lafayette, Indiana. This paper was previously circulated under the title 'The Cost of Hydraulic Fracturing: A Hedonic Analysis.'

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[1] Generally, the term 'unconventional' is used to refer to 'horizontal' hydraulic fracturing, in contrast to 'conventional' or 'vertical' hydraulic fracturing. Throughout the paper, we use the term unconventional natural gas extraction, and describe these different natural gas extraction techniques in detail in Section 2.

http://dx.doi.org/10.1016/j.reseneeco.2016.07.001
0928-7655/

these potential costs. In light of the scope of potential economic benefits and costs, as well as popularity in public debate, econometric estimates of these potential costs have the potential to substantially influence public policy.

There are few econometric studies that estimate the potential costs of unconventional natural gas production in the Marcellus Shale; these studies use the hedonic method to recover these costs. Gopalakrishnan and Klaiber (2014) find some evidence that shale gas extraction leads to a decline in home prices, ranging from about 1 to 7 percent. This decline in home prices is larger for homes that rely on well water. In their sensitivity analysis, Gopalakrishnan and Klaiber (2014) find mixed evidence that the significance of the decline in home values identified in their preferred specification is robust. Muehlenbachs et al. (2012) focus more narrowly on the external costs of groundwater contamination associated with unconventional gas extraction, and find that unconventional gas extraction wells cause a decrease of up to 24 percent of home values for properties that rely on groundwater resources, as opposed to municipal water sources. Muehlenbachs et al. (2015) focus on housing transactions in both Pennsylvania and New York, and find significant evidence of several possible impacts of shale gas extraction activities (including, for example, different effects on well water or municipal water homes). Finally, Boslett et al. (2015) find a significant decline in housing values in New York State in response to New York's shale development moratorium, and do not find a significant negative effect of shale development on Pennsylvania housing values.

Gopalakrishnan and Klaiber (2014) rely on data measured in the beginning years of the shale exploration and extraction boom (boom from 2008 to 2012) in order to minimize the potential for positive externalities of shale exploration or extraction to manifest in rising home values. This strategy may not be able to identify any longer run effects of shale gas exploration if the initial manifestation of externalities was either short lived or lower than the longer run effects. Muehlenbachs et al. (2012, 2015) provide an alternative identification strategy by using a triple difference approach (combined with matching in the later case) to account for unobservable factors that may be correlated with shale extraction activity. Finally, both Muehlenbachs et al. (2012) and Gopalakrishnan and Klaiber (2014) focus on Washington County. Parts of western Pennsylvania, which includes Washington County, have a relatively large amount of unconventional gas production; there is also a relatively long history of coal mining, conventional gas production, and other forms of resource extraction. It is not clear how this history may affect the results from an econometric study on the externalities associated with unconventional natural gas extraction. Furthermore, Washington County is relatively close to Pittsburgh; while it is possible to include some distance to Pittsburgh measure in a regression, it is not clear how to parameterize the model so as to adequately control for the effects of Pittsburgh when estimating the effects of unconventional gas extraction on property values. There may be complex and nonlinear interactions between Pittsburgh and the surrounding areas that are difficult to account for statistically.

Our paper builds on existing studies by focusing broadly on the overall environmental costs of unconventional gas extraction in the spirit of Gopalakrishnan and Klaiber (2014), while adopting robust econometric identification strategies that are, in some ways, similar to the models deployed by Muehlenbachs et al. (2012, 2015). We focus separately on two different counties in northeastern Pennsylvania – Lycoming and Bradford Counties – each with different strengths for econometric identification. Both Lycoming and Bradford Counties are home to relatively large amounts of shale gas extraction; Bradford County is home to the largest number of unconventional wells in Pennsylvania. However, (i) neither Lycoming nor Bradford County have been impacted much by any other type of natural resource extraction, including conventional natural gas extraction, and (ii) neither are home to any large cities. We contend that, in contrast to many other counties in Pennsylvania, both Lycoming and Bradford Counties are ideal counties in which to study the potential effects of unconventional natural gas extraction. Fig. 1 shows the location of natural resource industries in Pennsylvania, highlighting the location of both Lycoming and Bradford Counties (Washington County is located in the far southwest corner of Pennsylvania) and illustrating that these two counties are largely free from other resource extraction activities.

We make three distinct contributions in this study. First, we apply different techniques that rely on different assumptions for identification to the same data set to find if results are significant across our two counties in Pennsylvania and across different methods. This strategy allows us to assess the robustness of any statistically significant externalities. We focus on an area that has little of the legacy effects of coal mining and conventional gas extraction or urban development, while also containing relatively large amounts of unconventional gas extraction. This provides depth to the literature of the effects of shale gas development and alleviates any concern that complex interactions between alternative resource extraction activities or urbanity confound our estimates. In addition to dealing with econometric bias and confounding identification issues, our study area acts as a check on the external validity of results found in other studies.

Second, we employ two methods that reduce our dependence on linear estimates of effects. One is matching, which provides a flexible approach to imputing counterfactuals that tends to be more reliable in cases in which the linear regression structure is not well specified (Imbens and Rubin, 2015). We also estimate nonlinear effects of proximity to unconventional natural gas wells using a semi-parametric estimator that does not rely on a specific functional form of nonlinearity within the relationship between housing prices and shale wells. The virtue of this model is that it nests many common forms of nonlinearity, and does not require a priori specification of the model structure. These nonlinearities appear to be present and significant in the effects of distance to shale gas development in Bradford County.

Third, we use the border of the shale as an alternative means of identifying negative externalities of shale gas development. Lycoming County is unique in that there is a natural geological boundary in the Marcellus Shale that bisects the county.[2]

[2] Several other counties in Pennsylvania are bisected by this natural geological boundary, but none of these other counties are home to a large enough number of unconventional gas wells to allow for reliable econometric estimation. See panel (a) in Fig. 1.