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Research article

The impact of intensity on perceived risk from unconventional shale gas development

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ABSTRACT

The recent boom in the extraction of natural gas from subsurface shale deposits due to advances in hydraulic fracturing and horizontal drilling technologies has raised concern around environmental risks. Reliable measures of how residents view these risks are therefore a necessary first step in evaluating policies that regulate the industry through risk mitigation measures. We conduct a choice experiment targeting residents in an area of Ohio with significant shale drilling activity, and find that households are willing to pay to avoid high intensities of shale development and truck traffic. Our analysis presents new policy-relevant evidence of preferences associated with unconventional shale gas reserves, and highlights the tradeoffs between activity intensity at each site and the number of sites in aggregate.

1. Introduction

The development of hydraulic fracturing and horizontal drilling technologies has led to a boom in the extraction of natural gas from subsurface shale deposits in the past decade. The United States Energy Information Administration estimates that the contribution of unconventional shale gas in the total natural gas production in the United States has increased from less than 2% in 2000 to nearly 40% in 2014, and it is projected that this trend will continue (US Energy Information Administration, 2017). While these technologies have the potential to transform the energy sector in the United States, and provide economic benefits through lower energy prices (Mason et al., 2015; Linn et al., 2014), they also generate unintended negative impacts on human health and environmental quality. Policy responses to address potential unintended effects are further complicated by the wide ranging public perceptions regarding the risks from hydraulic fracturing with differences shown to vary based on demographic characteristics, education, and levels of awareness about the shale exploration process (Boudet et al., 2014).

Concern around environmental risks associated with hydraulic fracturing techniques has garnered media attention and generated interest from both scientists and policy makers (Olmstead et al., 2013). Controversies surrounding winners and losers from the unconventional shale gas boom depend on views about potential environmental and health risks. To address risks associated with shale exploration and drilling, policymakers have introduced several regulations at the state and local jurisdictional levels. These regulations are often a combination of price-based policy instruments (i.e., fees) and quantitative policy instruments (i.e., safety and technology standards) that determine the extent of risk mitigation measures required for shale exploration activity to be undertaken. For example, the state of Pennsylvania imposes an impact fee that is charged on a per-well basis to offset environmental impact of the activity (Act 13 of 2012's Chapter 23 relating to Unconventional Gas Well Fee).

In Ohio, the study area for this paper, drilling companies are required to test ground water wells within 300 feet of a proposed gas well in urbanized areas, and use a sampling method to test ground water within 1500 feet of a proposed horizontal well (Richardson et al., 2013). Ohio also implements water withdrawal and waste fluid disposal regulations, requiring operators to register and report the source and quantity of water withdrawal per day. Because fracking activity can damage and degrade roadways due to

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increased heavy truck traffic, states may require a Road Use Maintenance Agreement (RUMA) between drilling companies and local governments for repairs and road maintenance. In addition, a well operator in Ohio must acquire a written agreement with local governments before obtaining a drilling permit (Ohio Senate Bill 315, ODNR, 2012).

Policies to reduce the environmental impact of shale exploration differ significantly across states both in stringency and in the choice of regulatory tools, such as technological standards for casing and cementing, waste water fluid disposal requirements, permitting regulations, and severance taxes. These choices are often constrained by institutions, and regulators make policy decisions with incomplete information about the costs and damages associated with the environmental impact of an economic activity. To evaluate the suite of command-and-control and tax policies, we first need reliable measures of environmental impacts and perceptions surrounding shale activity. In this paper, we estimate the willingness to pay to avoid risks associated with shale extraction activity using data from a survey of Ohio residents in counties with shale activity. We conduct a choice experiment – a discrete choice survey method that elicits individual preferences by asking participants to make choices over hypothetical scenarios – to recover estimates of the cost of shale risk. Our work provides new policy insight by focusing on potential tradeoffs between targeting the aggregate number of shale drilling sites and the intensity of activity at each site.

The remainder of this paper is organized as follows. In the next section, we review the existing literature on the environmental impact of shale exploration activity. We discuss evidence of a variety of environmental risks such as water and air pollution and forest fragmentation, as well as the impact of these risks on residents. In Section 3, we present the survey design and the choice experiment that we conducted. We then discuss the survey data collected from residents in 9 shale-rich counties in Ohio. In Section 5, we present the econometric analysis and estimates of willingness to pay to avoid shale related activity. The final section concludes with a discussion of policy implications.

2. Environmental impact and risks from shale exploration

Academic interest in the environmental and health impacts of unconventional shale gas development has grown exponentially over the past two decades. A Web of Science search for scientific publications that include "shale impact" in the topic indicates over 1000 journal articles and conference proceedings published between 2000 and 2017 across fields of natural and environmental sciences, engineering, and the social sciences. However, less than 40 of these documented studies focus on the economics of shale risks. Whereas the physical and geochemical effects of hydraulic fracturing technology are well established, estimates of the willingness to pay to avoid the direct and indirect impacts of shale development are comparatively sparse.

Existing work on potential risks from shale activity has consistently shown the existence of negative impacts on surface and ground water that require policy intervention to mitigate these risks (Olmstead et al., 2013; Osborn et al., 2011). The process of hydraulic fracturing to extract shale gas contributes to groundwater contamination from the release of methane and chemicals into aquifers. Methane concentrations in drinking-water wells in shale-rich regions of New York and Pennsylvania were found to be an order of magnitude higher in samples from wells located within one mile from an active extraction site, relative to wells located farther from shale sites (Osborn et al., 2011).

Potential ground water contamination from shale activity also negatively impacts surrounding housing prices (Gopalakrishnan and Klaiber, 2014; Muehlenbachs et al., 2015). Studies using housing sales combined with unconventional shale gas development activity from Pennsylvania show that the negative impact on housing prices is large for groundwater-dependent homes located close to the drilling activity (Muehlenbachs et al., 2015) and this effect attenuates both with distance from the drilling site and over time; the largest impact (7%) is observed on houses located within a mile from the drilling site and sold within three months from obtaining a permit to drill (Gopalakrishnan and Klaiber, 2014). Recent empirical work that combines spatial information on unconventional shale gas development in Pennsylvania and Ohio with household data on bottled water purchases provides further evidence of perceived water risks. Wrenn et al. (2016) show that an average household in active shale development counties spent between $10 and $15 USD in 2010 on bottled water purchases to avert potential risk from water contamination (Wrenn et al., 2016).

A study in New York implemented a choice experiment in which residents choose among electricity options, where a subset of the options contained electricity generation associated with hydraulic fracturing. The study finds that there is a substantial welfare loss associated with energy production from hydraulic fracturing, and that welfare is decreasing with proximity to well sites. The authors also find that respondents rate negative impacts of hydraulic fracturing as more important than positive impacts when responding to Likert scale questions (Popkin et al., 2013). Stated preference surveys have also been employed to examine how different sources of information alter views of risks associated with unconventional shale gas, and the willingness to pay to avoid those risks (Siikamäki and Krupnick, 2014). In this study of public preferences in Pennsylvania and Texas, authors find robust evidence that households were willing to pay to avoid environmental risks, including surface water and traffic congestion, but this willingness to pay was sensitive to the source of information about those risks. A survey of experts in government, industry, and academics identifies water quality risks from leakage of chemical laden fluids, disruption of surface water flows, increase in air pollution from particulate matter during the fracturing process, and inconvenience to communities from increased truck traffic as important sources of environmental risk (Krupnick and Gordon, 2015; Small et al., 2014).

Shale exploration can also have a significant impact on forest cover as the construction of new roads and increased truck traffic between water withdrawal sources and well pads lead to forest loss and fragmentation (Davis and Robinson, 2012; Drohan et al., 2012; Racicot et al., 2014). Klaiber, Gopalakrishnan, and Hasan (2017) examine the impact of shale exploration activity on forest cover and forest fragmentation in Pennsylvania and show that every additional shale drilling site results in approximately 50 acres of forest cover loss. Because well sites are, on average, observed to operate below their full capacity of 8–12 wells, this paper suggests that a conscious clustering of shale wells would conserve more than 100,000 forested acres in Pennsylvania alone (Klaiber et al., 2017). In the absence of stringent regulations for clean-up and forest restoration after shale extraction (Muehlenbachs, 2015), this could reflect a potential permanent loss of forest cover, with significant implications for carbon sequestration and other ecosystem benefits.

These types of growing environmental concerns have resulted in policy regulations aimed at decreasing the perceived negative impact of unconventional shale activity. One feasible mitigation strategy that is afforded by advancements in directional drilling is the clustering of well sites, thereby decreasing the landscape footprint required to extract shale gas reserves (Abdalla et al., 2012). While clustering generates potential environmental benefits due to the decreased spatial footprint of exploration activity, the potential impact of high intensity activity on local residents