EARTHQUAKE ALLEY: UNCONVENTIONAL OIL AND GAS DEVELOPMENT, INDUCED SEISMIC ACTIVITY, AND HOUSING PRICE IMPACTS

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Overview

This study seeks to identify the economic impacts with unconventional oil and gas production. Our identification strategy consists of linking geographically proximate housing values to natural gas development, underground wastewater injections, and induced earthquake activities within Oklahoma County, Oklahoma. Using an instrumental variables approach, we provide robust evidence that production, wastewater disposal, and seismicity are negatively impacting property values. Compared to other findings within this nascent literature, this study corrects for two types of prior biases: the inherent measurement error associated with seismic events, and the endogeneity of underground injection well sites and residential housing prices. Our robust findings suggest that the swarm of earthquakes within Oklahoma County have generated, on average, a 1-to-4 percent reduction (approximately USD 1500-to-6000) in housing values.

Methods

This study offers three major contributions to this small but growing literature. One, we provide new evidence of the economic impacts associated with human-induced earthquakes. Two, we use self-reported measures of seismic activities (U.S. Geological Survey's "Did you feel it?" data) to estimate the impact of earthquakes on housing prices. Three, the study uses an instrumental variables (IV) approach due to the potential endogeneity of injection well sites and housing locations.

Results

We find that an additional earthquake of magnitude 3.0 or larger, generates an average 1-to-4 percent near-term reduction in property values (since the swarm of seismic events started in 2007). Further, we find that nearby underground injection wells and production wells consistently put downward pressure on housing values, although the effects are smaller than that of the earthquake impacts. These findings are robust to a battery of housing characteristics and time invariant fixed effects. Based on the estimated reduction in values, we calculate the total average per-household costs, associated with induced earthquakes in Oklahoma City, are approximately USD 1500-to-6000.

As in Koster and van Ommeren (2015), we address the issue that the induced earthquakes and residential housing locations do not necessarily occur randomly over space. Based on this insight, we posit that there is a potentially simultaneity bias between injection well sites and housing (transaction) locations. Intuitively, this endogeneity problem could stem from numerous potential causes, including (but not limited to): historic oil and gas production wells (which decades later become underground injection wells) are located in poorer neighborhoods; and, wealthier neighborhoods having the resources to orchestrate collective action against wastewater injections (for example, "Not in My Backyard" campaign efforts).

Conclusions

Our findings have implications for state policies regarding the regulations of wastewater injections into disposal wells. Based on our impact estimates, we believe the state of Oklahoma (or a jurisdiction within all or part of the Oklahoma City MSA) has three potential policy avenues to address this issue: (1) business as usual; (2) treat induced earthquakes as negative externalities; and (3) institute a seismicity compensation fund. With the first policy option, the State could do nothing and simply allow for its citizens (or earthquake insurance providers if applicable) to assume the risks from possible earthquake damages to private property. The policy option for the business-as-usual case does have one potential caveat though. That is, it is not clear if a standard earthquake insurance policy would cover damages from human-induced earthquakes (Summars, October 4, 2015). In other words, several standard earthquake policies only provide coverage for natural occurring damages. However, some policies are now carving out coverage specifically for earthquakes not naturally occurring, such as earthquakes attributed to wastewater injection from hydraulic fracturing activities (National Association of Insurance Commissioners, 2017). Hence, a government or regulatory agency may need to ensure that its private citizens, who reside within a seismically prone region, have the proper type of insurance coverage given the increase in frequency and severity of (induced) earthquake activities (Monies, September 8, 2016).

With the second policy option, the State could treat the induced earthquakes as a negative externality and levee a corrective tax (or impact fee) to provide a source of public funds to compensate individuals for potential future impact damages. According to Richardson et al. (2013), there are currently 26 states in the U.S. that levee a severance tax for crude oil and natural gas production. Pennsylvania assesses an "impact fee" against operators in counties that choose to impose the fee. However, these types of taxes generally are not related to environmental regulations at all (Richardson et al., 2013). To the best of the authors' knowledge, no state in the U.S. has legislated a tax or impact fee (based on environmental regulations) assessed against direct environmental impacts (including induced seismicity) associated with oil and natural gas development. Instead, most states have elected to simply monitor and regulate (or outright prohibit as in the case of North Carolina) underground injection of fluids produced in the extraction of oil and gas (Richardson et al., 2013). In a similar vein, the Oklahoma Corporation Commission, which has exclusive jurisdiction to regulate class II underground injection wells, launched a plan (starting in 2015) to heavily monitor and reduce the risk of induced earthquakes.

A third policy option for the State would require a supplementary industry-level insurance or compensation fund, collected through production levees against individual shale gas developers (Konschnik, 2017). The fund would pay out compensation for large environmental damages that would otherwise be impractical to recover from individual funds (Daniel et al., 2017). According to Daniel et al. (2017), this would give the industry (within a particular state or jurisdiction) to self-regulate, by monitoring member firm's efforts to limit environmental (or seismic) risks and thereby contain the production fees. A similar type of arrangement has been established with International Oil Pollution Compensation Funds, which provide financial compensation for pollution damages caused by oil spills, among other types of accidents (IOPC Funds, 2017).

Our findings also have implications for states located in neighboring regions where the unconventional oil and gas development is taking place. For example, the state of Pennsylvania did not adopt the primacy of the U.S. Environmental Protection Agency's (EPA) underground injection controls (UIC) program; therefore, the EPA implements the State's UIC program (U.S. EPA, 2015). As such, a large volume of wastewater from Pennsylvania is disposed of in the neighboring states of West Virginia and Ohio. If seismicity is definitively linked to wastewater injections, then interstate disposal of natural gas and oil production wastewater could potentially require heavier future federal oversight as production in one state is arguably linked with seismic activity in a neighboring state. The case of cross-state induced seismicity would seem to clearly constitute a negative externality, which implies perhaps federal intervention and regulation.