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State regulation of unconventional gas development in the U.S.: An empirical evaluation

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ABSTRACT

U.S. production of unconventional natural gas has increased rapidly over the last decade, and triggered public concerns about a variety of related risks. State policymakers vary in how they design regulatory policies to balance the anticipated risks and benefits, few attempts have been made, however, to evaluate the heterogeneity in state unconventional gas regulations. In this analysis, we develop a framework for comparing states based on how intensely they regulate unconventional gas development. We utilize two separate but complementary methodological approaches to investigate regulatory heterogeneity: an expert elicitation survey and principal components analysis. Our results indicate that, even though there is significant heterogeneity in state regulatory systems, there exist clusters of states that are consistently ranked at the top or the bottom along a continuum of regulatory stringency. States such as West Virginia, Colorado, Louisiana, New Mexico and Pennsylvania are found at the top of this scale, while at the lower end we find California, Tennessee, Mississippi and Montana. As states refine their regulatory systems, these rankings can be updated to reflect new policy and regulatory priorities.

1. Introduction

Production of natural gas from unconventional reservoirs employs advanced technologies such as horizontal drilling and hydraulic fracturing. The use of these technologies has encouraged a rapid increase in U.S. gas production over the last decade [92]. The boom in U.S. unconventional gas development (UGD) is also partly attributable to government policies that have helped promote technological innovations in the industry, the private nature of royalty-based property rights framework surrounding mineral and land ownership (private vs. publically held), the extensive availability of gas reserves on private land, and the high natural gas prices in the 2000s [96]. UGD potentially provides significant opportunities for economic development in the localities in which it is extracted. The scientific community, however, has yet to arrive at a consensus regarding the nature and magnitude of the risks associated with of UGD.

Development of oil and gas resources is regulated on three levels of government; federal, state and local. Because of the variety in operating conditions and circumstances, state regulations have evolved historically to become the most prominent component in the UGD regulatory framework. State regulators aim to balance the competing considerations arising from the risks and benefits of UGD. Documentation of state regulatory efforts is challenging, however, because each state has its own statutory mandates, administrative rules and regulations, as well as caselaw rulings handed down by the courts. The regulatory systems also vary in their transparency, extent of documentation, and accessibility. Information on the structure and stringency of these policies and regulations, however, can inform our understanding of UGD developments and the manner in which different jurisdictions may weigh the various benefits and risks associated with UGD developments.

Policy scientists have documented a degree of regulatory heterogeneity between states. Several studies have compared UGD regulations in small groups of states. Few studies, however, have analyzed this heterogeneity across all states with UGD so as to provide a complete picture of the regulatory landscape. The objective of this paper is thus to provide an empirical evaluation of the regulatory environment of UGD across all applicable states, and develop regulatory rankings that can inform both our collective understanding of the UGD policy environment as well as policymakers that operate within this domain seeking to compare their regulatory approach to that of other states. It is important to note that our evaluation of the regulatory environment does not consider regula-

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tory enforcement. While incorporating enforcement would provide a more complete picture of regulatory heterogeneity, data availability would make such an effort rather challenging. Furthermore, an additional constraint in our study is that we do not distinguish between de jure and facto regulation, that is, the difference between the way the regulations are explicitly worded and the way they are applied by government officials in practice. It could be the case that while de jure regulations appear less stringent (i.e. UGD process regulated on a case by case basis) government officials have the expertise and authority to ensure sufficient safety standards for public health and the environment. Additionally, there is significant uncertainty regarding the most effective regulatory regime for governing UGD; that is, whether it should consist of adaptation of existing conventional oil and gas rules or development of new regulations specifically tailored to UGD. To date, no empirical evaluation of which of those two regimes would be preferable has been conducted and published.

This study employs a two-part analysis. First, we conduct an expert solicitation to rank UGD regulatory elements in their importance to public health, safety, and the environment, as well as the level of difficulty developers may face in complying with regulatory programs. We use the input from a group of experts to develop indices that capture the degree of stringency in state regulations. Second, we estimate regulatory indices using the statistical methodology of principal component analysis (PCA). This technique uses data-driven weights to rank regulatory elements, and therefore provides an alternative to the weights based from the expert elicitation. The combination of these two efforts allows us to evaluate and rank states' regulatory approaches to UGD through different but complementary techniques, and draw insights regarding individual state's regulatory stringency and the broader regulatory environment across all applicable states.

This analysis is a single-country study, focused specifically on the U.S. regulatory landscape. While a country-level comparative analysis would potentially provide more generalizable insights, we limit our analysis to the U.S. context for the following reasons. First, there is enough variability in UGD regulations at the state-level that comparison of these differences is meaningful, and the number of states with oil and gas statutes provides a big enough sample to make a U.S. comparative study feasible. This is in contrast with all other locations around the world that would not lend themselves as neatly to such a comparative approach. Second, the regulatory context and design features of other countries' policies are meaningfully different and therefore render it difficult to compare in a single cross-national analysis.

Our analysis begins with a discussion of the benefits and risks of UGD that are most frequently discussed in the literature, so as to set the context for regulatory developments. The second section summarizes the extant UGD literature within the energy and environmental policy realms. Next, we present the results of both methodological approaches. The paper concludes with a discussion of the results, policy implications, and future research needs.

1.1. UGD benefits

Economic benefits from UGD accrue to a series of stakeholders beyond simply the developer. One of the direct benefits of UGD is a revenue stream that mineral estate owners receive when they convey these rights to developers [20,39,51]. Within the United States, the fact that mineral rights are designated as private property that can be used for the financial benefit of the individual, has been attributed as one of the main drivers of the exponential growth of UGD [96]. Typically the transaction entails the leasing of mineral rights, which includes both a one time "bonus" payment—dollars per acre for the parcel—and a royalty payment, as a percentage of the value of the oil and gas produced from the land if drilling is found to be productive. Bonus payments to mineral owners vary but average $2,700–6,000 per acre in the mid-Atlantic Marcellus region [9,31]. Depending on the value of the potential production, developers offer a wide range of bonus payments and royalty percentages. While the standard percentage of a royalty interest is 12.5%, percentages can be negotiated to higher levels. The federal government, being the largest land and mineral estate owner in the nation, collects significant revenue through this means [100]. States as well as local governments also collect royalty payments in a similar manner through leasing of state and municipal lands. Furthermore, financial benefits can accrue to local governments as well. As an example, the state of Pennsylvania has an "impact fee" which channels revenue on production to the state and then a portion back to the local communities in which development is taking place.

Severance taxes offer another form of economic benefit, as accrued by local and state governments. Severance taxes are "*gross royalties or taxes based on the gross volume or value of output*" [38]. In some cases the tax is based on the value of the resource that is extracted, depending on market prices, while in others it is determined as a fixed amount of the quantity of gas produced [71]. Severance taxes on UGD are viewed favorably by many states as a way to improve state fiscal health. Even states that traditionally favor low tax rates, such as Texas, Wyoming, Montana or Alaska, have adopted severance taxes for UGD [69].

UGD has the ability to stimulate the local labor market and provide other positive benefits. Studies have estimated a varying amount of labor gains attributed to UGD [17,50,99]. Considine et al. [17] estimate that in Pennsylvania investments of $4.5 billion by shale gas developers generated more than 44,000 jobs. [99], on the other hand, estimates that UGD jobs created in Pennsylvania will be just over 2100. Part of the divergence in these results is due to the differences in assumptions, such as whether the labor market gains generated in a county are directed towards non-county residents, the magnitude of economic multipliers, and the extent to which the industry reinvests the profits to expand development in a given county. Recent data from the Bureau of Labor statistics indicate that within the 2007–2012 period the oil and gas sector in Pennsylvania experienced an increase in employment of 15,114 Cruz et al. [104]. The authors attribute this increase to UGD.

There are also indirect benefits of UGD in those portions of the manufacturing sector that use natural gas as a feedstock. The supplies of natural gas have become so plentiful in the U.S., thus increasing domestic energy security, that some companies are beginning to redirect capital investments from abroad to the US. Such corporate behavior is particularly apparent in the chemical industry [35,41,77,87].

1.2. UGD risks

The potential risks of UGD for public health, safety, environmental quality, and economic development are the subject of a growing body of scientific evidence. Risks featured most prominently in the literature and media relate to seismic activity, air quality degradation due to local pollutants, surface and groundwater contamination, fugitive methane as a greenhouse gas, threats to biodiversity due to forest and habitat fragmentation, the potential for increased traffic accidents in localities with UGD, as well as the threat of the boom and bust cycle of resource extraction.

The possibility of triggering seismicity in association with UGD has been recognized as a possible safety risk of the practice [30,33,37,48,49,73]. While small levels of seismic activity have been correlated with the process of stimulating and flowing back gas wells, the primary concern is associated with the disposal of high volumes of produced waters into the deep subsurface via injection wells [63]. The risk associated with induced seismicity is consid-