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Institutions and the shale boom

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Abstract. This paper uses the institutional economics of Douglass North to explain three features of the shale boom: why fracking technology emerged in the United States, the rapid increase in production of natural gas in the United States and the uneven response to these new economic opportunities in shale-rich economies. It argues that the institutional matrix of the United States, in particular private ownership of minerals, encouraged experimentation on the barren Texas oil and gas fields, where fracking technology emerged and the rapid transfer of mineral rights to gas companies. Institutional entrepreneurs, namely landmen and lawyers, facilitated contracting between owners of mineral rights and drillers. Private ownership of minerals and an ideology supportive of drilling provide insight into the adoption of regulations that encourage hydraulic fracturing.

1. Introduction

Oil and gas is conventionally extracted by drilling downward and then allowing underground pressure to force minerals to the surface. The ease of extraction also presents an economic problem. When many individuals have access to a reservoir, they often have incentives to race to capture oil and gas (Anderson and Hill, 1990). The conventional economic solution to a pumping race is establishing a collective property rights to the reservoir through a unitization agreement (Libecap and Wiggins, 1985; Wiggins and Libecap, 1985). Unitization encourages conservation by making each of the individuals a co-owner in the joint production of the reservoir who bear a personal cost from over-extraction. In Demsetz's (1967) language, unitization encourages internalization of the externalities associated with conventional oil and gas extraction.

A tremendous amount of natural gas is also contained in shale formations (U.S. EIA, 2015). However, downward drilling does not force shale gas to the surface because shales are relatively impermeable (Zuckerman, 2013b). These challenges of extracting shale gas mean that a pumping race is not as much of a problem with shale production (Holahan and Arnold, 2013). At the same time, they also ensured that shale gas was not worth much economically until relatively recently. The economic profitability of shale gas changed with the combination of horizontal drilling and fracturing shale with chemically treated

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water. Although none of these techniques were new, their combination is similar to a new technology for extracting shale gas (Fitzgerald, 2013). The result has been a rapid increase in economic growth in shale-producing regions in the United States (Hausman and Kellogg, 2015).

Institutional approaches to hydraulic fracturing typically consider the extent to which governance institutions are capable of internalizing the economic externalities and risks associated with hydraulic fracturing (Holahan and Arnold, 2013; Small *et al.*, 2014). This paper complements these studies by analyzing how the structure of institutions explains the origins of the shale boom and variation in the political response to new economic opportunities presented by fracking technology. It uses insights from the institutional economics of Douglass North to explain three features of the shale boom: why fracking technology emerged in the United States, the rapid increase in production of natural gas in the United States and the uneven response to these new economic opportunities in shale-rich economies.

My take on a Northian explanation for the shale boom can be summarized as follows. Private ownership of minerals in the United States created incentives for drillers to experiment for decades to figure out ways to profitably extract natural gas from shale, and then facilitated contracting between owners and gas companies once fracking technology emerged. Legal institutions, in particular dominance of the mineral estate (which requires surface owners to allow the owners of mineral rights reasonable access to them), trespass decisions favorable to drillers, and compulsory pooling, further encouraged shale production. Institutional entrepreneurs, in particular lawyers and landmen, economized on transaction costs confronting gas companies, owners of mineral rights and surface owners. Variation in the structure of property rights (in particular, whether individuals or the state owns mineral rights), along with ideology, which in North's framework refers to the subjective perceptions of the actors, provides insight into difference in the political response to hydraulic fracturing among U.S. states, as well as why some shale-rich countries have very little shale production (e.g., Britain) or have lagged behind the United States in shale production (e.g., Argentina and China).

The importance of institutions as a fundamental cause of economic growth is now mainstream (Acemoglu and Robinson, 2001; Acemoglu *et al.*, 2005). Much of the recent work in institutional economics seeks to identify the causal impact of institutions on outcomes, in particular through field or natural experiments (Blattman *et al.*, 2014; Olken, 2007, 2010; Yoo and Steckel, 2016). These studies, while providing many insights into the consequences of institutions through clever research designs, sometimes neglect factors that do not fit neatly into the institutional story (Kopsidis and Bromley, 2015). In contrast, the approach in this paper bears more in common with North's (1956, 1966) early work on the American economy, which described how the institutional matrix of the country provided an rather ideal framework for economic growth during the 18th and

19th centuries. Elements of the institutional matrix include the Bill of Rights, separation of powers, federalism, the Northwest Ordinance (which established self-governance and private property rights in the new territories of the U.S. government) and democracy, along with institutions that facilitated competition among political parties. This concept of the institutional matrix does not lend itself to a neat identification of the causal impacts of institutions, yet North offered a convincing argument that the combined effect of these institutions was to encourage innovation and a rapid response to new economic opportunities. This paper provides another important example how the institutional matrix of an economy explains the origins of innovation and variation in the adoption of innovations.

This paper is organized as follows. Section 2 uses North's perspective on institutions to formulate hypotheses regarding the shale boom. Section 3 offers an institutional interpretation of the U.S. shale boom. Section 4 suggests that variation in the extent of private ownership explains differences in the response of several shale-rich countries to the shale boom. Section 5 concludes.

2. Institutions and economic performance

One of the fundamental themes in North's work is the importance of private property rights as an explanation for economic growth. North and Thomas (1973) illustrate the argument using evidence from the economic history of Western Europe. According to North and Thomas, European monarchs from the 16th through 18th centuries had a choice between establishing private property rights to encourage production and to increase the state's long-run revenue base or to expropriate wealth, thereby increasing revenue in the short run but undermining long-run economic growth. They found that countries that responded to fiscal crises arising from war and disease by establishing and strengthening private property rights (England and the Netherlands) experienced more economic growth than those that responded with predation (France and Spain).

North and Thomas also used evidence for England to illustrate a theory of the origins of private property rights. In their interpretation of English history, freeholders developed alienable property rights because the Norman conquest left England with a stronger central government than the rest of the feudal world but not so strong as to be able to expropriate private property. After the King's Court established jurisdiction over freemen, manorial lords lost control over their landholdings, while in continental Europe, the revival of Roman law did not afford lessees legal protection, as tenants were subject to arbitrary eviction and hereditary lease was not allowed. This political context enabled freemen to enclose the 'wastelands' in the countryside, which subsequently saw increasing agricultural production and set the stage for the Industrial Revolution.

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The example of England suggests the importance of political interests and institutions in the emergence of private property rights. The economic theory of the state makes this point more explicit in arguing that state consolidation enables specification and enforcement of private property rights. According to the economic theory of the state, the consolidation of state power improves property security because the monopoly on coercion makes the sovereign a residual claimant in production whose expropriations are now personally costly (North, 1981; North and Thomas, 1973). McGuire and Olson (1996) and Olson (1993) formalized this argument in showing that a stationary bandit, which is how they described the state, has incentives to respect private property rights, provided coercive power is unquestioned.

The early versions of the economic theory of the state did not have much of a role for political constraints. Rather, the extent to which the monarch centralized coercive capacity was the deciding factor in the emergence of private property rights (Murtazashvili and Murtazashvili, 2016). North and Weingast (1989) subsequently clarified the importance of political constraints, using the Glorious Revolution to illustrate how separation of political power can improve investment incentives. Although subsequent economic history questioned whether investment actually increased after the Glorious Revolution (McCloskey, 2010), the importance of tying the king's hands for the emergence of property rights is now widely accepted (Diermeier *et al.*, 1997; Gehlbach and Keefer, 2011; Riker and Weimer, 1993; Root, 1989; Weimer, 1997). Federalism, for example, is thought to improve the government's commitment to market institutions (Bednar, 2008; Myerson, 2014; Weingast, 1995).

Another important aspect of North's institutional economics is the role of entrepreneurs, which are source of both innovation in the economy and change in economic institutions. Productive entrepreneurs, who typically take the institutional context as given, induce economic change through decisions about which activities to finance (Kirzner, 1978). North's work on the American economy emphasized the importance of institutions that encourage productive entrepreneurs to take risks. However, there is also a second tier of institutional entrepreneurs who specialize in modifying and adjusting institutions (Leeson and Boettke, 2009). North (1990), as well as Knight and Sened (1995) and Knight (1992), also acknowledged the importance of this second tier of entrepreneurs in arguing that individuals and organizations put pressure on institutions in response to changes in relative prices, and in some instances, may supply institutions themselves in response to new economic opportunities. For example, North (1990), along with Libecap (1989) and Umbeck (1977), argued that squatters on the American frontier during the 19th century established their own private property institutions when the government failed to recognize their presumptive claims to ownership.

Institutional entrepreneurs also economize on the transaction costs that arise during the process of bargaining over property rights. According to Coase (1960),

the government's role in the economy is to assign property rights and then to allow the market to allocate ownership through a competitive process. According to this perspective, government or courts can increase the efficiency of the allocation process by intervening in the economy when transaction costs prevent reallocation of property rights through markets to those individuals or groups who value them the most (Coase, 1937; Komesar, 1994; Williamson, 2005). However, governments and courts are not the only actors who can resolve these transaction costs. Institutional entrepreneurs may also specialize in reducing transaction costs associated with contracting for property rights.

North also provided many insights into the process of institutional change. According to Knight and North (1997), the mechanisms of institutional change can be divided into efficiency or distributional conflict. The early theories of institutional change assumed that economic actors would realize that the absence of property rights institutions reduces social surplus and petition politicians to specify and enforce private property rights (Demsetz, 1967). North (1981) even suggested that competitive pressure would lead to the adoption of efficient institutions, which he defined as changes in rules that increase social surplus. Such change can be described as Pareto-improving institutional change (Riker and Weimer, 1995).

The efficiency perspective on institutional change has been criticized as offering a naive theory of the political process (Eggertsson, 1990). One of the puzzles for these early theories is that private property rights often do not emerge, or emerge only after long delays, even though the open-access losses may be readily apparent. Subsequent work introduced 'political parameters', which include political and bureaucratic interests, as well as conflict over the gains from contracting for private property rights, as factors that constrain the adoption of efficient institutions (Libecap, 1989; Sened, 1997). The generalization of this perspective is the distributive theory of institutional change. According to the distributive theory of institutional change, the bargaining power of groups, bureaucratic incentives and political power each undermine prospects for Pareto-improving institutional change.

North's (1990) explanation for inefficiency in the process of institutional change initially suggested that organizations obstruct adoption of institutions that promise to increase social surplus. He later folded the role of organizations into the distributive perspectives above. Subsequently, North consider ideology, which he conceptualized as a part of the mental models of the actors, as a mechanism of change in institutions. Mental models are the subjective perceptions held by individuals that influence beliefs about how institutions will work. This perspective suggests that the choice of institutions in the economy will reflect the ideological perceptions of individuals, not simply a desire for economic efficiency (Acemoglu, 2003; Denzau and North, 1994; North, 2005).

The importance of private property rights, entrepreneurs and ideology were also present in North's early work on economic growth in the United States in

the 18th and 19th centuries. These early studies argued that 'good' institutions facilitated the economic development of the American frontier (North, 1956, 1966). The great land ordinances of the early Congresses, in particular the Land Ordinance of 1785 and the Northwest Ordinance of 1787, established the rectangular survey system, which provided a rational and orderly system to allocate land for private use throughout the 19th century, as well as provided for self-governance in the new territories (North and Rutten, 1987). Subsequent studies provide evidence that the orderliness of the rectangular survey system, in particular in comparison to the more complicated 'metes and bounds' system, increased economic development (Libecap and Lueck, 2011). These ordinances also established auctions to allocate public land to citizens through a competitive process that promised to provide the new American state with a source of revenue during a period in which the capacity of the federal government to tax citizens was almost non-existent (Murtazashvili, 2013). Political ideologies supported private ownership of land, including the Republican Party, which prior to the Civil War adopted a party platform that included plans to establish a nation of free men who would earn their living by working land given to them by the government (Foner, 1971). Constitutional rules encouraged competition between groups, as well as provided the foundation for an open and inclusive political order (North *et al.*, 2009). Finally, constraints on the central government, including federalism and the Bill of Rights, encouraged economic development by making it more costly to the government to expropriate private property (Mittal *et al.*, 2011; North, 1990; Weingast, 1997).

North also appreciated the role of path dependence in the process of institutional change (Riker and Weimer, 1993; Weimer, 1997). Path dependence refers to how past institutional choices influence the development of political and economic institutions (Mahoney and Thelen, 2009; Pierson, 2000). Such processes also involve institutional refinement, whereby new institutions evolve or are designed through change of institutional elements, while supplementing existing institutions or responding to their failures (Greif and Laitin, 2004). In U.S. economic history, path dependence and institutional refinement favored institutional innovation and long-run economic growth because the early institutions encouraged creation and accumulation of wealth.

These insights can be summarized as several hypotheses for the shale boom:

(1) Hydraulic fracturing technology emerges in economies that reward innovation through private ownership of minerals;
(2) Private ownership of minerals encourages contracting for property rights between drillers and owners of mineral rights;
(3) Emergence of institutional entrepreneurs facilitates contracting between drillers and owners of mineral rights;
(4) Private property rights and an ideology supportive of private ownership increase pressure on politicians to adopt regulations that encourage drilling.

3. The political economy of the American shale boom

The United States is the home to several massive shale formations. The Barnett Shale in Texas was the first major shale play in the country but has recently been surpassed by the Marcellus Shale, which lies beneath Pennsylvania, Ohio, West Virginia and New York (U.S. EIA, 2015). The most comprehensive economic studies find that shale-producing regions in the United States are associated with more economic growth, lower unemployment, improvements in the local tax base, and that the USA has largely avoided a resource curse as a result of hydraulic fracturing (DeLeire *et al.*, 2014; Fetzer, 2014; Hausman and Kellogg, 2015; Weber, 2012; Weber *et al.*, 2016). The structure of property rights, institutional entrepreneurs and an ideology supportive of fracking provide insight into the emergence of fracking technology and the rapid increase in shale production that followed these innovations.

Property institutions

A property right is a bundle of rights that can be divided or subdivided as society sees fit. The surface and mineral estates are often divided, or severed (Ellickson, 1993). Once the surface and mineral estate are severed, the mineral estate may be owned individually, by a community or by the government.

One of the defining features of the property institutions governing oil and gas in the United States is that much of the mineral wealth of the nation is privately owned (Bradley, 1996). In contrast, the state owns minerals in much of the rest of the world. However, there is substantial state ownership of minerals even in the United States, especially in the American west.

One of the main reasons for the persistence of state ownership in the United States is an important change in federal land disposal policies in the early 20th century. The federal government acquired over a billion acres of the land in the 19th century. Initially, the federal government did not make much of an effort to retain mineral rights as it sought to transfer state-owned land to individuals, in part because squatters asserted *de facto* ownership rights to land and minerals (Murtazashvili, 2013). This situation eventually changed, as the federal government began to reserve mineral lands, such as with the Stock Raising Homestead Act of 1916 (Gates, 1977). This act extended the homestead principle of free land to additional western states but added the provision that the federal government would retain all rights to mineral lands, mainly to coal, which was viewed as increasingly important to national security. One of the consequences of this change in policy is that there are many federal split estates in the west, which refers to situations in which surface land is privately owned and the government owns the mineral estate (Fitzgerald, 2012). Split estates are also common in the east, but most are private split estates, whereby different private parties own the surface and mineral estates. A study of drilling on the Marcellus shale found that between a third and two-thirds of land in counties

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where there has been drilling are private split estates, while the rest are private unified estates (Collins and Nkansah, 2015).

These institutional features are important because one expects the strongest link between private ownership and drilling in the case of private unified estates. Private split estates may make contracting more challenging in comparison to a unified estate because the gas companies do not have to worry about opposition from surface owners, although institutionalized dominance of the mineral estate, discussed below, eases the ability of gas companies to contract with mineral rights owners in the case of private split estates. When the federal government owns the mineral estate, contracting is expected to be less rapid, North's perspective expects less innovation or production (or both).

One of the reasons for innovation appears to be private ownership of minerals. The Texas lands where fracking was developed known as the 'Wildcatter's Graveyard'. It was in many ways like the wastelands on the English countryside in the sense most thought them to be of little economic value before they were brought into production. George Mitchell earned his reputation as the 'father of fracking' for investing in these lands that nobody else wanted (The Economist, 2013b). Mitchell Energy spent $250 million drilling shale over sixteen years but had almost nothing to show for it until 1997, when drillers almost by accident figured out that they could use chemicals to make the fracturing fluid work more efficiently to extract shale (Zuckerman, 2013a). These investments paid off, as several wildcatters, including Mitchell, became billionaires after selling their companies (Zuckerman, 2013a, 2013b).

Private ownership of mineral lands ultimately paid off for Mitchell, who did not patent his inventions. Rather, he made fortunes buying vast amounts of cheap land and then selling them at higher prices (Golden and Wiseman, 2015). His story is one of innovation, purchase of property and development that was made possible because he could acquire vast amounts of land that he could then sell to others at a high price once his company developed the right combination of technologies to make fracking profitable. In this regard, fracking technology supports Moser's (2013) contention that patents may not drive innovation and growth. Yet private property rights are important in this story – even if it is not a story about intellectual private property – because the opportunity to own vast amounts of lands and the minerals is what made Mitchell and a few others their riches.

Private ownership of minerals also created incentives for the owners of mineral rights to contract with gas companies. The major economic reason why owners of minerals have incentives to contract with gas companies is because they can receive an up-front bonus along with a royalty payment. In Texas, many became rich quickly as a result of the shale boom, which increased support for hydraulic fracturing in the region (The Wall Street Journal, 2012). During the height of the shale boom in Pennsylvania, more than $1 billion a year was transferred to mineral rights owners (The Economist, 2013a).

The importance of private ownership is also illustrated by considering hydraulic fracturing when the government owns the mineral estate. Theoretically, federal ownership of mineral lands increases the transaction costs of production (Fitzgerald, 2010). Indeed, there is less shale production when the federal government owns the surface lands or the mineral estate (Humphries, 2013; Mason 2013).

There are also a number of legal institutions that encouraged drilling by strengthening the property rights of mineral owners. Institutional economists have long recognized that courts create new property rights when they decide conflicts between owners and others in society (Bromley, 2006; Commons, 1924). One is dominance of the mineral estate. In mineral-rich states, surface owners generally have to allow reasonable access to minerals. This has its origins in the common law, which held that the mineral estate would not be worth much unless the owners have reasonable rights to access those minerals (Walker Jr, 1928). The mineral estate remains dominant in Texas (Fry *et al.*, 2015). Texas courts have also sided with industry in trespass cases. *Coastal Oil & Gas Corp. v. Garza Energy Trust* (Tex. 2008) applied the rule of capture to subsurface trespass caused by hydraulic fracturing, which protects the interests of those who sign leases, rather than the landowners who have not (Wiseman, 2009). Finally, most states have adopted, and courts have supported, compulsory pooling, including Texas (Fry *et al.*, 2015; Holahan and Arnold, 2013). Compulsory pooling encourages drilling because it forces mineral rights owners to participate in drilling.

The structure of private property rights also provides insight into why states maintain low rates of taxation on shale production. In many contexts, the state is unable to secure much of the scarcity rent from natural resource extraction (Bromley, 2009; Libecap, 2007). One of the defining features of shale extraction is the effective tax rate in all shale-producing states is very low (Weber *et al.*, 2016). Distributive theories of institutional change have long emphasized bargaining power as an explanation for who gets what in politics (Knight, 1992; Knight and North, 1997). Private ownership and accumulation of wealth are each sources of bargaining power that likely constrain the ability of the state to extract more of the scarcity rent from shale production.

The challenge of adopting a severance tax in Pennsylvania illustrates the distributive logic. Pennsylvania initially established an impact fee on hydraulic fracturing that amounted to an extremely low tax on production – in fact, lower than in any other state (Rabe and Borick, 2013). The perception that the state was not receiving its fair share led to a prolonged conflict to replace the impact fee with a severance tax that would represent a boon to the central government and a much larger tax on industry (Legere, 2016). Although the severance tax would amount to 6.5% of production and is estimated to bring in over $200 million annually in revenue, it has yet to be adopted and had been the subject of major political controversy (Phillips, 2016).

Entrepreneurs

Productive entrepreneurs, as exemplified by George Mitchell, had an important role in the shale boom for reasons noted above. North's framework complements studies of entrepreneurship by pointing out that their incentives reflect the institutions of society, in particular private property rights to minerals. Institutional entrepreneurs, in particular landmen and lawyers, also played an important role. Their role in the shale boom is to alleviate the transaction costs that could have undermined the contracting process. Shale production requires assembling large amounts of land to achieve economies of scale. The well pad for a fracking operation is fairly small – around five acres – which reduces it ecological footprint (Sovacool, 2014). However, drillers have to accumulate vast amounts of land to achieve economies of scale. For example, Chesapeake Energy holds least acres in the United States (15 million lease acres), including 1.5 million lease acres of the Marcellus shale. Drillers also have to file royalty-sharing agreements for a 'unit' to ensure some equity of distribution of the gains from drilling. In Pennsylvania, units are usually between 100 and 500 acres, with royalties prorated based on shares of acreage in a unit, subject to a minimum royalty of 12.5% of the value of hydrocarbons produced (Kelly-Detwiler, 2013).

Fracking thus involves large amounts of land. The size of the land areas associated with fracking ensures that gas companies will have to negotiate with a large number of people, not only for some of whom own the surface and mineral estate, but also many for whom the surface and mineral estate are severed. The *Garza* case, although it was ultimately supportive of drillers, nonetheless affirmed that the gas companies in general require permission from all owners before drilling or else they may be trespassing on land. All of this amounts to substantial transaction costs of contracting.

Landmen, who can be both independent and work for gas companies, are a solution to these transaction costs. Landmen search the deeds records in a community to understand who owns what mineral rights and then inform any mineral rights owners of their rights (Wilber, 2012). Although landmen are depicted as unscrupulous in the Hollywood's 2012 blockbuster about the rush to drill, *Promised Land*, they also have an important economic function, which is to facilitate contracting for property rights.

To the extent that landmen often work for gas companies, they cannot be expected to produce an 'efficient' bargaining solution. Indeed, in many instances, land owners do not understand the value of their land and feel at a disadvantage in dealing with gas companies (Timmins and Vissing, 2014). There is also some evidence that minorities and poorer individuals negotiate deals with gas companies that are less likely to include provisions to protect surface land or also the payment for land (Vissing, 2015). To the extent, these are simply distributive consequences, they do not undermine social surplus from contracting – it must means a transfer of rents from consumers to producers (Tullock, 1967). However, these distributive issues are important questions of

public policy even if they are not necessarily a source of inefficiency (Bromley, 1991). In addition, the bargains over surface damages involve externalities – as source of social surplus losses – and so if certain groups are less likely to bargain with gas companies to get them to internalize these costs, then there are social surplus losses arising from disparities in the bargaining process. Thus, even though landmen may serve an important economic function, it would be unwise to view them uncritically as a source of efficiency in the bargaining process. Nonetheless, landmen are typically independent contractors who are trained by agricultural outreach programs at many of the nation's major universities (Etter, 2015). They also have their own association that certifies them as experts in a trade. Regardless of whether they are efficiency-enhancing or not, it seems reasonable to conclude that they facilitated the contracting process necessary for the shale boom.

Wallis and North (1986) conceptualized of lawyers as a response to transaction costs. In the context of contracting for shale rights, one of the ways that lawyers economize on transaction costs is by organizing landowners. In a number of communities in the Marcellus region, lawyers informed citizens of the process of leasing land and came up with a generalized lease with provisions favorable to landowners (Wilber, 2012). By providing information to landowners about provisions that are important to include in a lease, lawyers may reduce the social costs arising from insufficient regulations protecting surface owners. They also facilitate contracting by reducing the bargaining problem from many to one player. When many owners bargain separately, costly delates in contracting for property rights are more likely (Libecap, 2005, 2009). By organizing landowners, lawyers can reduce the bargaining problem from many parties with many opportunities for breakdown to a bilateral bargaining situation between a firm and a single bargaining entity. Of course, landowners may also assemble on their own, without lawyers (Fry *et al.*, 2015). In such cases, the lawyers serve a more conventional function of providing a service for landowners, rather than as a solution to a coordination problem.

Ideology

The discussion above suggests that private property rights created a constituency to support drilling. However, the U.S. states have varied tremendously in their response. In fact, there are over 30 different efforts to regulate hydraulic fracturing (Richardson *et al.*, 2013). North suggested that ideology may explain variation in public policies. Although North (2005) emphasized the mental models of policymakers as an explanation for mistakes in the process of institutional change, the theory also suggests that variation in ideologies of citizens will explain differences in the choice of institutions.

A comparison of New York and Pennsylvania is a particularly useful to evaluate the hypothesis that ideology influences the process of institutional change. The main reason is because property rights and economic incentives

to frack were similar in these two states but the regulatory responses were quite different. In New York, individuals signed thousands of leases with gas companies (Navarro, 2011). Yet the government of New York responded with a moratorium because of uncertainty associated with hydraulic fracturing (McKinley, 2013). In addition, many local governments in New York banned fracking (Arnold and Holahan, 2014). Pennsylvania, in contrast, became a worldwide leader in shale production.

Economic studies seeking to isolate the impact of property rights often select cases where geography, culture and ideology are similar but property rights and growth outcomes differ (Acemoglu *et al.*, 2002, 2003). The purpose of doing this is to isolate the role of property rights on economic outcomes. A similar logic can be used to show how ideology influences the political response to the shale boom. Geography, economic benefits and private ownership of minerals are similar in these states but the regulatory response to shale has different dramatically. Thus, if ideologies in these states differ, then it is a plausible explanation for variation in the regulatory response.

The available evidence is consistent with the hypothesis that ideology explains difference in policies in these states. Public opinion polls show that people in Pennsylvania prefer fracking more than in New York (Cusick, 2014). Such polls suggest that policy preferences differ, but ideology refers to deeply held beliefs. For this reason, it is necessary to consider whether liberals are more likely to oppose fracking and whether New York has more liberals than Pennsylvania.

It is also fairly clear that New York is a more liberal state than Pennsylvania (Gelman, 2009). Popular accounts suggest that opposition to hydraulic fracturing is driven in part by liberal politics, in particular emanating from New York City (Gabriel and Davenport, 2016). The journalistic narrative is often one of a liberal gentry and socialites against rural landowners (Siegel, 2013). Public opinion research finds that liberals are more likely to oppose fracking in New York (Kriesky *et al.*, 2013). Ideology also appears to influence adoption of local policies governing shale in New York (Arnold and Holahan, 2014). Polling data from the United States also shows that liberals are less supportive of fracking. (Boudet *et al.*, 2014). In light of this evidence, it is at least plausible that differences in ideology may explain variation in the political response to fracking.

Although the reasons above suggest ideology matters, it may also be the case that private property rights also matter, even in these two states. One interesting possibility is that people who signed leases now realize that if the leases expire because of regulatory delay, they could sign better deals (Navarro, 2011). Those who signed leases may want to wait to overturn the ban until their leases expire so that they can then seek better terms. In addition, those who signed leases in New York and Pennsylvania are more likely to support fracking, which suggests property interests are an important explanation for support for policies governing fracking (Kriesky *et al.*, 2013). It therefore seems reasonable to

conclude that private property rights and ideology each contribute to divergent responses to fracking.

4. The comparative political economy of the shale boom

One of the most intriguing features of the shale boom is the dramatic differences in the ways in which shale-rich countries have responded to new opportunities presented by hydraulic fracturing. Although Europe has vast shale wealth, production to date has been almost non-existent. Some of the challenges are 'below ground', which refers to differences in geography that make fracking Europe more of a technical challenge. But many are 'above ground', which refers to political conflict that undermines fracking, such as in France, where the government was quick to ban fracking (The Economist, 2013). Britain issued a moratorium on fracking in 2010, but quickly reversed its stance. Ex-Prime Minister David Cameron was a strong proponent of fracking in Britain, even proclaiming that the country would go 'all out' for shale (The Economist, 2015). However, no wells have been drilled in Britain event though a moratorium was lifted in 2012.

Private ownership of minerals creates a powerful constituency with an interest in promoting fracking. In this regard, the mineral rights owners are the kind of group that Olson (1965) viewed as more likely to influence politics – small groups with common interests. This factor works in favor of drilling in the United States. The property situation is different in Europe, where the government owns mineral rights. State ownership of minerals reduces economic incentives for individuals on the land to support hydraulic fracturing. In contrast to the United States, where the new class of wealthy landowners had incentives to lobby for fracking, European landowners have few self-interested reasons to pressure the government to allow fracking because they do not necessarily get the bonuses or royalties.

Argentina is another country with vast amounts of natural gas in shale but very little shale production to date. Part of the problem is government regulation (The Economist, 2014a). However, the deeper challenge may be a structure of property rights that creates few incentives for individuals to support fracking. Although mineral wealth brought prosperity to barren lands in the United States, public ownership of minerals in Argentina reduces incentives for innovation and risk-taking to the extent that people in mineral-rich lands to move from those lands (Yeatts, 1997). The delay in shale production is another example of a more general theme in the economic history of Argentine mineral extraction, which is how excessive regulation and state ownership of minerals undermines development prospects.

China may seem like a counterexample to the hypothesis that private property encourages shale production. After all, China has increased shale production despite state ownership of minerals. However, the Chinese got in the shale game

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late and the country has scaled back shale production goals (The Economist, 2014b). Although much more work comparing the United States and Chinese cases need to be done, one expects that state ownership contributed to less innovation in China (and greater reliance on technology developed elsewhere), a slower response and less ambition to overcome the geological challenges confronted by shale extraction.

5. Conclusion

Much of the economics research on shale is concerned with externalities associated with hydraulic fracturing, such as its consequences for property values (Muehlenbachs *et al.*, 2015) or public health (Olmstead *et al.*, 2013). However, it is also important to understand why, when and where the shale boom occurred. Economic historians have devoted much attention to the timing and location of the Industrial Revolution. It is also useful to think in a similar way about the shale boom.

North's work anticipates the importance of the institutional matrix of the economy as an explanation for the shale boom. Private ownership of minerals in the United States provided incentives for innovation in hydraulic fracturing technology. Once new technology emerged, private ownership facilitated contracting between gas companies and the owners of mineral rights. Legal protections of the owners of mineral rights, such as dominance of the mineral estate, protection of drillers from trespass lawsuits and compulsory pooling, further encouraged contracting for property rights between owners and gas companies. The legal framework also encouraged profit-motivated lawyers and landmen to offer services to reduce the transaction costs of contracting. Variation in ideology and the structure of property rights help to explain why the response to new opportunities varies in the United States, as well as differences across economies in the response to new technologies.

There are a number of ways to build upon the institutional analysis presented in this paper. Much of the institutional literature on the management of common pool resources considers how the interaction of social, ecological, economic and political variables explains the extent to which resource extraction is sustainable (Cole *et al.*, 2014; Ostrom, 1990, 2007, 2009). Such approaches have already shown why unitization is less relevant for addressing externalities associated with hydraulic fracturing than with conventional oil and gas extraction. The reason is that conventional oil and gas extraction does not have the same sorts of externalities, such as groundwater pollution, that are associated with fracking (Holahan and Arnold, 2013). It would be useful for future research to more fully integrate the insights from research on the commons with studies that view private ownership as a source of innovation and adoption of new technologies of extraction.

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A large institutional literature considers the importance of decentralized, polycentric governance of natural resources (McGinnis and Ostrom, 2012; Ostrom *et al.*, 1961). Although studies of the commons often praise decentralized governance, there has been vigorous debate over the appropriateness of polycentric governance of hydraulic fracturing (Arnold and Holahan, 2014; Spence, 2013). Recent work by North *et al.* (2009) suggests that decentralized political institutions encourage innovation. Polycentric governance promises to encourage experimentation with hydraulic fracturing regulation, and may be a source of regulatory innovations, although more research is necessary to clarify the benefits and costs of polycentric governance.

There is also much to be learned by digging deeper into the process of institutional change. One way to do this is by expanding the concept of mental models beyond ideology to include some of the factors emphasized by the 'old' institutionalists, such as how habits and cultures influence institutional emergence and change (Hodgson, 1998). For example, a culture of private ownership may also have facilitated the shale boom. It would also be useful to consider including factors emphasized in behavioral economics in North's perspective on institutional change. Much of behavior economics considers risk perceptions (Kahneman and Tversky, 1979). Recent work suggests that the newness of technology leads to misperceptions about the extent of risk and underestimates the ability to manage risks of hydraulic fracturing (Graham *et al.*, 2015). The concept of mental models could be expanded to include not only ideology, but habits and culture, along with cognitive limitations emphasized by behavioral economists.

North's institutional economics illuminates the big questions associated with the shale boom. It offers a plausible explanation why technology emerged in Texas, why this technology was adopted so quickly and why a number of shale-rich economies have been slow to respond to new economic opportunities. The explanatory framework focuses on the role of private property rights and entrepreneurs, although it also accounts for ideology in the process of institutional change. North's framework can also be expanded to include habits, culture and flawed human cognition. Even without modification, it remains a wonderfully useful approach to understand the origin of innovation and the adoption of innovations, as well to understand the diversity of institutions and regulations adopted in response to new economic opportunities.

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