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UNCONVENTIONAL EXPLORATION IN BRAZIL: NO DOING, NO LEARNING

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Abstract

Due to uncertainties regarding the environmental impacts of unconventional oil and gas exploration, these activities have been suspended in the country until further knowledge is obtained and the detailed regulation is put in place. Given that most of the knowledge acquisition in unconventional exploration is obtained in a learning-by-doing process, the suspension will greatly reduce the ability to attain more knowledge needed to establish appropriate regulations, making this approach very ineffective. The most promising policy mechanism to reduce environmental uncertainties in an industry in which learning-by-doing plays a central role is the adoption of information disclosure policies. Information collection and public dissemination policies would not only avoid errors and redundancies, but also accelerate the learning process, inducing higher productivity gains.

Keywords: Unconventional exploration, learning-by-doing, precautionary principal.

1. Introduction

Unconventional oil and gas exploration can benefit the market in several ways. Unconventional exploration typically involves onshore fields with lower sunk costs and shorter lead times than most of Brazil's oil and gas production derived from deep-water offshore fields. Given these characteristics, unconventional exploration tends to stimulate the emergence of a competitive fringe that can help stabilize the market, by enabling quicker supply responses to market price fluctuations.

In spite of these benefits, unconventional oil and gas exploration in Brazil has been suspended due to safety and environmental concerns. The main rationale for the suspension is

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that, given the current uncertainties regarding the environmental impacts of unconventional exploration, the most prudent course of action is to adopt the 'precautionary principle', postponing production until further knowledge is obtained.

The problem with this rationale is that most of the knowledge regarding unconventional oil and gas exploration is acquired by a 'learning-by-doing' process. Because of the practical nature of unconventional exploration and the specificity of each particular oil play, there is little that can be learned in the absence of drilling. Thus, the postponement of unconventional exploration does not foster a better understanding of the environmental risks and how to abate them.

The objective of this paper is to identify adequate public policies for the development of unconventional oil and gas exploration in Brazil. The evaluation begins with an examination of the economic benefits that unconventional oil and gas exploration can provide. Next, a brief summary of the current situation of unconventional exploration in Brazil is presented. Then an analysis of policies that can be adopted to foster prudent unconventional exploration, so as to minimize potential negative environmental impacts is presented.

2. Potential Benefits of Unconventional Oil and Gas Exploration

Unconventional exploration could benefit the Brazilian economy in numerous ways. The most obvious benefit is its potential to increase oil and – especially – gas production. Brazil's current proven conventional natural gas reserves is of the order of 15 TCF (trillion cubic feet). According to the government's preliminary analysis, unconventional exploration could amplify the natural gas reserves by a factor of ten – bringing to the market an additional 156 TCF of natural gas by 2050 (CTMA/PROMINP, 2016).

This boost in onshore natural gas production would not only greatly expand natural gas supply, but also provide greater flexibility. This is an important factor, particularly to the Brazilian electric power industry, which is derived primarily from renewable power sources. Natural gas thermal power plants play a strategic role in this context, complementing the stochastic supply derived from hydro, wind and solar production. Currently this complementation is limited because of the rigidity of natural gas supply. Brazil's natural gas supply is currently provided primarily from: (i) domestic associated gas; (ii) imported natural gas under strict take-or-pay provisions; and (iii) higher-cost imported liquefied natural gas. With a more flexible natural gas supply, the electricity matrix could be optimized to provide higher reliability at a lower cost.

Another potential benefit of unconventional oil and gas exploration is the structural changes it can bring about in the oil and gas market. The economics of unconventional oil and gas exploration differs from that of conventional exploration. Unconventional exploration is characterized by smaller operations, smaller reserves, and faster decline rates. These characteristics make unconventional exploration more attractive to small-independent firms – that are more flexible and nimble – than to oil majors (Wang and Krupnick, 2015; and Chyong and Reiner, 2015). Thus unconventional exploration tends to foster the entry of new and smaller players into the market, forming a competitive fringe that can bolster competition.

Another characteristic of unconventional exploration is the great variability of costs. Resource assessment and production forecasts (even in the same oil and gas plays) can vary significantly. Costs also vary widely, not only due to varying geological conditions, but also due to the availability of local transportation infrastructure needed to get the oil or gas to the market. The resulting heterogeneity of costs implies that unconventional exploration is characterized not by one, but by a range of break-even points (Ikonnikova *et alii*, 2015). This results in a positively inclined aggregate-supply function that enables smoother supply adjustments to changes in the market price.

Furthermore, the lead times required by unconventional oil and gas exploration is much shorter than deep- and ultra-deep-water offshore projects, which account for most of Brazil's oil and gas production. Unconventional exploration projects can typically be planned, drilled and completed in months, while the time required to put an offshore project into operation is often of a decade or more. These shorter lead times help reduce the oil and gas industry's long-lived price overshoots (Kleingerg *et alli*, 2016). The more rapid decline rates also contribute to make suppliers adjust more quickly to changing market conditions.

Together these factors have fundamentally changed global oil market dynamics. Unconventional oil production has not only affected oil pricing directly, by its contribution to aggregate supply, but also indirectly, by influencing OPEC's (Organization of the Petroleum Exporting Countries) production policies. Utilizing a structural vector autoregressive model it is possible to identify shifts in OPEC's production reaction to non-OPEC production in 2014, when unconventional oil production peaked at 9.5 million barrels per day (compared to 5.4 million barrels per day – just four years earlier). In the aftermath of the global financial crisis, OPEC adopted an "accommodative approach", restricting supply to boost oil prices. But in 2014, in light of the increasing supply of unconventional oil, OPEC switched to a "strategic approach" to preserve its market share. OPEC boosted supply, prompting a steep fall in oil prices. The maneuver sought to shake off the unconventional oil producers. Unconventional oil production declined in the coming years, but it did not drive them out of the market and when OPEC members decided to cut supply by 1.8 million barrels per day, at the end of 2016 to push oil prices back up, unconventional oil producers readily boosted production. Thus the emergence of unconventional oil production changed the supply behavior of the major market players (European Central Bank, 2017; Kim and Lee, 2017).

The potential benefits from unconventional exploration can extend much beyond the oil and gas markets. As stated by the European Central Bank (2017): “Commodities, and oil in particular, remain the most important source of volatility in consumer price inflation.” Thus, unconventional oil and gas production can play an important role in promoting macroeconomic stability.

2.2 Current State in Brazil

Brazilian policymakers intended to initiate unconventional oil and gas exploration In June 2013, when the National Council of Energy Policy (*Conselho Nacional de Política Energética – CNPE*) authorized the inclusion of exploratory blocks classified as “Mature Basins” and as “New Frontiers” in Brazil’s 12th Oil and Gas Bidding Round, specifically mentioned the nonconventional exploration. The objective of the 12th Round was to expand the oil and gas exploration frontier of onshore basins in Brazil and to stimulate the entry of small- and medium-size producers to promote greater competition in the industry. The Tender Protocol and Concession Contracts established minimum exploration requirements with the objective of providing a better understanding of the geological conditions and exploratory potential in the various basins.

After the Bidding Round was completed, however, multiple civil action suits were filled, demanding the immediate suspension of unconventional exploration activities.

The most common argument presented by Federal Prosecutors in the various suits is that unconventional exploration should be postponed until better knowledge is obtained on the potential environmental impacts. Appealing to the Precautionary Principal, the judicial injunctions require that exploration be conditioned to a strategic environmental assessment of the potential impacts of unconventional exploration and the laying of out specific regulation for hydraulic fracturing (‘fracking’) activities.

To meet public concerns, the government commissioned ‘Environmental Assessment of Sedimentary Area’ (*Avaliação Ambiental de Área Sedimentar*). Furthermore, a Task Force, led by staff of the Ministry of the Environment (*Ministério do Meio Ambiente*) and of the

Mines and Energy (*Ministério de Minas e Energia*), was commissioned to formulate an integrated governance framework for unconventional exploration in Brazil. The Task Force presented a report in May 2016; nevertheless, the legal uncertainty associated to unconventional exploration remains (Zeitoune e de Sá Ribeiro, 2013; CTMA/PROMINP, 2016; and MME, 2017).

3. The Economics of 'Learning-by-Doing'

The academic literature reveals that much of the learning in unconventional exploration is gained from on-site experimentation of different exploration techniques. Horizontal drilling and hydraulic fracturing techniques have now been in use for decades. Yet, unlike most technological innovations, the key to unconventional exploration is the adaptation and fine-tuning of particular techniques to the specific exploration site. Productivity is achieved through practice, self-perfection and minor innovations. The determination of the optimal well design (number of wells to be drilled, location, depth…), the decision of how much hydraulic fracturing to pursue (pressure and duration employed) and the choice of the most effective fluids (used to open fractures to enable the flow of oil and gas in tight rock formations) and grains (used to keep the fractures open) are highly specific to particular geological conditions. Learning in this context is obtained primarily from on-site empirical experimentation (Wang and Krupnick, 2015; Ikonnikova *et alii*, 2015; Redlinger, 2015; Kleingerg *et alli*, 2016).

The key feature of industries subject to learning-by-doing is that unit costs decline with accumulated output or production, similar to what is observed in industries subject to economies of scale. Thus, as production increases, productivity is increased, boosting production even more. The main difference between learning-by-doing and economies of scale is that early entrants gain an advantage over latecomers entering particular segments of the market (Spence, 1981).

In spite of the early-entrants' advantage, learning-by-doing in the case of unconventional exploration does not lead to market dominance – as predicted in the theoretical model developed by Cabral and Riordan (1994) – because the long-run productivity gains from learning-by-doing are limited by the specificity of each oil and gas play. As the oil and gas producer moves from one location to another, experimentation and adaption to the particular characteristics of the new geographical location are needed. This feature has helped preserve the low concentration levels of the fringe and thus of its competitive pressure.

The diversity of conditions in different oil and gas plays also limits the aggregate, long-term productivity gains. Thus, the autonomous compounding of aggregate productivity due to predicted by learning-by-doing theoretical models is not to be expected in unconventional oil and gas industry (Ritchie and Dwlatabadi, 2017).

One of the useful insights obtained from the model presented by Spence (1981) is that multiple *equilibria* are possible. For example, there may be situations in which no firm enters the market because it is initially unprofitable. The activity is only profitable after a certain threshold of learning is achieved. This is a case in which research and development incentives may be necessary to jump-start the learning-by-doing process.

Part of the learning-by-doing is also associated to the relationship-specific learning between: (i) oil producers, responsible for the technical design and planning of wells to be drilled and transportation logistics; and (ii) drilling rigs, that actually conduct the drilling of wells (Kellog, 2011). This effect is not robust in all empirical specifications, however, suggesting the effect is relatively small (Redlinger, Lange and Maniloff, 2016).

Thus, policies should seek ways to foster the acquisition of knowledge and its dissemination so as to enable widespread application of the best practices.

5. Policy Recommendations

For the acquisition of better understanding of unconventional exploration potential in Brazil and of its potential environmental impacts, it is imperative that field trials be allowed. The knowledge that can be derived from theoretical studies and from foreign experience is limited. To obtain more pertinent and in-depth knowledge of unconventional exploration in Brazil, unconventional exploration should be allowed on a limited basis, accompanied by the following measures: adoption of a monitoring program to ensure safety, promotion of industry best-practice guidelines, and setting of minimum reporting requirements to promote the dissemination of the knowledge acquired.

Policies of this sort have been put in place in various jurisdictions. Although direct governmental regulation is usually the first aspect considered, the United States experience demonstrates that other mechanisms of internalizing externalities are very effective. For example, industry best practices guidelines, such as that of the American Petroleum Institute and the Center for Sustainable Shale Development, have been very influential. There are various accounts of companies that have chosen to follow these best practices even when they surpassed the regulatory requirements. Another mechanism that has been important in the United States has been the judicial system. Legal liability laws have played an important role in driving operators to adopt practices aimed at reducing risk. Finally, governmental initiatives to collect and release data on production, well integrity tests, inputs utilized, methane emissions, environmental impacts, and leaks can be very helpful to promote efficiency, security and to improve public policies (Krupnick, Richardson and Gottlieb, 2015).

Given the important role of learning-by-doing in unconventional exploration, policies aimed at promoting the dissemination of unconventional exploration could not only increase safety but also promote efficiency. Redlinger (2015) finds no evidence of learning-by-doing spillovers from one operator to another. This implies that each operator must learn on his or her own, resulting in large redundancies. This "inefficient learning" process could be circumvented by information disclosure policies. North Dakota, currently the second largest oil-producing state in the United States, has adopted such policies, collecting and publicly disclosing detailed data on each completed well. Detailed information on the well's location, horizontal length, fracking input choices, and audited production records are made public after six months. The delay was established to provide a temporary advantage to the early entrant so as to stimulate experimentation and innovation. Covert (2015) has analyzed the learning behavior in North Dakota, and concluded that firms fail to take full advantage of the policy. The main reasons given for these shortcomings are: (i) risk aversion – firms prefer streamlining production to obtain certain production cost savings, to experimenting with a different fracking design that promises higher – but less certain – profits; and (ii) "own-data bias" – firms have different priors regarding the relation between different production choice, which lead firms to give more weight to their own data and experience than to that obtained from other producers. In spite of the lackluster results, this information disclosure policies are one of the most promising mechanisms to promote safety and efficiency in the industry.

6. Conclusions

Given the benefits obtainable from unconventional oil and gas exploration and the fact that most knowledge acquisition is obtained by learning-by-doing, policies should be crafted to foster knowledge acquisition and sharing so as to minimize environmental impacts, promote safe practices and optimize production.

The best course of action to mitigate uncertainty is not to suspend unconventional exploration, but rather to enable exploration on a limited scale, with proper regulatory oversight, and collection and dissemination of information obtained in the exploration of these oil and gas plays. From the experience gained at these experimental fields one can then craft appropriate regulations for exploration on a wider scale.

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