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The geopolitical impact of the shale revolution: Exploring consequences on energy prices and rentier states

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HIGHLIGHTS

- We quantitatively explore geopolitical consequences of the shale gas revolution.
- We use a multi-model approach to generate and use energy price scenarios.
- Simulations show that current low oil prices could be part of a hog cycle.
- The shale gas boom was an early warning for the drop in oil prices.
- Low prices due to shale gas can reduce internal stability in rentier states.

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ABSTRACT

While the shale revolution was largely a US' affair, it affects the global energy system. In this paper, we look at the effects of this spectacular increase in natural gas, and oil, extraction capacity can have on the mix of primary energy sources, on energy prices, and through that on internal political stability of rentier states. We use two exploratory simulation models to investigate the consequences of the combination of both complexity and uncertainty in relation to the global energy system and state stability. Our simulations show that shale developments could be seen as part of a long term hog-cycle, with a short term drop in oil prices if unconventional supply substitutes demand for oil. These lower oil prices may lead to instability in rentier states neighbouring the EU, especially when dependence on oil and gas income is high, youth bulges are present, or buffers like sovereign wealth funds are too limited to bridge the negative economic effects of temporary low oil prices.

1. Introduction

In recent years, a spectacular rise in natural gas extraction capacity from unconventional resources has dramatically changed the US' energy landscape, turning the country into a natural gas exporter. This development is often referred to as the 'shale gas revolution' and was made possible by the process of hydraulic fracturing, or 'fracking'. As a consequence of the shale gas revolution, US' gas prices have dropped significantly, giving a competitive advantage to the US' industry. The spectacular rise in extraction of shale oil resources only adds to that advantage.

The shale revolution was thus far largely an US' affair, as outside of Northern America hardly any commercial exploitation of shale resources took place. This can be primarily explained by institutional differences between the US and other countries (Kuuskraa et al., 2013; Tian et al., 2014), as significant technically recoverable shale resources can be found outside of North America (Kuuskraa et al., 2013). Notwithstanding the fact that the shale revolution has not spread across the world (Melikoglu, 2014), the large-scale extraction of shale deposits has affected the global energy system through LNG trading, which is still a minor part of global natural gas trade (BP, 2015), and through substitution of other, easier transportable primary energy sources. The impact of the shale revolution on global energy markets is the starting point of this research.

Research regarding the impact of the shale revolution mainly focussed on direct extraction effects like the effects of shale gas

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drilling on the environment (e.g., Baranzelli et al., 2015; Jenner and Lamadrid, 2013; Kargbo et al., 2010; Meng and Ashby, 2014; Olmstead et al., 2013), the public support for shale gas and fracking (e.g., Boudet et al., 2014; Jaspal et al., 2014; Perry, 2012), and the impact on the local economy (e.g., Asche et al., 2012; Kinnaman, 2011; Lee, 2015). In some research, the economic impact was related to energy security (e.g., Jaspal et al., 2014; Richter and Holz, 2015; Victor et al., 2014). Others studied the impact of shale gas exploration on energy prices, mainly for oil and gas (e.g., Asche et al., 2012; De Silva et al., 2016). Asche et al. (2012) acknowledged that it would be interesting to look at the interplay with coal, another primary energy source, which we do in this paper. However, to the best of our knowledge, more indirect consequences of the shale revolution have not been investigated.

One of these potential indirect effects is the impact of the shale revolution on intra-state stability of major oil and gas exporting countries, also referred to as 'rentier states' (Mahdavy, 1970), through changing oil and gas prices. Price fluctuations may have consequences for the financial-economic stability of rentier states due to the dependence on 'resource rents' (World Bank, 2011) for supporting the economy and government spending. That is, fluctuations in resource prices may influence the development of the local economies in oil and gas exporting countries. In turn, worsening economic conditions are known to have an impact on population discontent, potentially leading to intra-state instability (Collier and Hoeffler, 2004; Ross, 2004). Similar indirect effects may occur due to structural changes in the global energy system induced by climate mitigation policies. However, these effects are complex and uncertain.

Both the global energy system and the relation between resource income and instability are highly complex and deeply uncertain. Feedback effects add to dynamic complexity (Sterman, 2000). An example of a feedback effect in the global energy system is the interaction between supply and demand which results in resource price dynamics. On a country scale, decreasing resource prices may lead to increasing unemployment and a reduction of purchasing power, which may cause frustration among the population and reduce internal stability. This feedback loop is closed if state instability in turn affects resource extraction. Both the global system and national systems are also characterised by 'deep uncertainty' (Lempert et al., 2003). Situations are deeply uncertain if they are characterised by important presently irreducible uncertainties related to how issues could or should be modelled, likelihoods of inputs and outcomes, and the desirability of outcomes. To give examples: on a global scale, the strength of the feedback effect between prices and demand is deeply uncertain, while on a national scale, the influence of population discontent on a country's polity is also deeply uncertain.

Complexity and uncertainty impede mental simulation of both the global energy system and state stability (Sterman, 1994). Quantitative simulation may enable one to deal with these issues though. Since the 1950s, modelling and simulation approaches have been developed and used to support policy-makers and decision-makers addressing complex issues. Since the early 1990s (Bankes, 1993), model-based methodologies and techniques have been developed to simulate sets of models under deep uncertainty.

In this paper, we use simulation models to explore the indirect consequences of the shale revolution on the global energy system and rentier state stability. For this purpose, we apply a 'systems-of-systems' (DeLaurentis and Callaway, 2004) multi-model approach for dealing with complexity and uncertainty. We use a global energy-mix model for supply, demand, and trade of, and substitution between six primary energy sources to generate oil and gas price scenarios. In these scenarios, the focus lies on price scenarios that fall outside the scope of more traditional forecasts of energy prices using a base-case (e.g., IEA, 2012). These scenarios are subsequently used as input for a country-stability model, focussing on economic discontent (i.e., 'greed' in Collier and Hoeffler, 2004). As such, the price scenarios are used for stress testing rentier state country stability, more specific those in the vicinity of the European Union (EU). These countries are Algeria, Azerbaijan, Kazakhstan, Qatar, Russia, and Saudi Arabia.

The setup of this paper is as follows. In Section 2, we explain the use of Exploratory Modelling and System Dynamics in this study, the model structures of the energy-mix model and the country-stability model, and the metrics for choosing 14 price scenarios. Based on these scenarios, we present the results on country stability by taking Algeria and Russia as examples in Section 3. Finally, we discuss the results of this approach in Section 4, and draw conclusions regarding the geopolitical consequences of the shale revolution in Section 5.

2. Methods

In this research, we use an exploratory modelling scenario approach. First, we simulate and investigate the consequences of the shale revolution to generate global oil and regional gas price scenarios. Second, a subset of these price scenarios is used to stress-test intra-stability of rentier states in the vicinity of Europe. In this section, we introduce this model-based scenario approach (Section 2.1), as well as the modelling and simulation method (Section 2.2), and the two models used in this research (Section 2.3). At the end of this section we explain the research setup in more detail (Section 2.4).

2.1. Exploratory Modelling

'Exploratory Modelling' is a research methodology that uses computational experiments to analyse deeply uncertain issues (Bankes, 1993; Bankes et al., 2013; Kwakkel and Pruyt, 2013; Lempert et al., 2003). It consists of a set of the development of plausible quantitative simulation models and associated uncertainties, the process of exploiting the information contained in such a set through a large number of computational experiments, the analysis of the results of these experiments, and the testing of promising policies for policy robustness (Bankes, 1993).

In exploratory modelling, models are used to generate a wide variety of what-if scenarios, which is an important use case of simulation models (Oreskes et al., 1994). These what-if scenarios are usually generated such that they comprehensively cover presently irreducible uncertainties. Exploratory modelling, therefore, does not focus on generating a base case, but instead on generating a bandwidth of plausible futures, including the circumstances (i.e., ranges of specific uncertainties) for which these occur.

2.2. System Dynamics

System Dynamics (SD) is a modelling and simulation method to describe, model, simulate, and analyse dynamically complex issues or systems (Forrester, 1961; Pruyt, 2013; Sterman, 2000). The SD approach was first proposed and developed by Jay W. Forrester in the late 1950s. SD aims to provide a holistic and systemic view of an issue under study and its interconnections to its environment, and simulate and analyse the resulting system dynamics over time. More specifically, SD is a method for modelling and simulating dynamically complex systems or issues characterised by feedback and accumulation effects (Sterman, 2000).

Together, feedback and accumulation effects generate dynamically complex behaviour both inside SD models, and, so it is assumed by System Dynamicists, in real systems (Pruyt, 2015).