KAPSARC
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King Abdullah Petroleum Studies and Research Center

Analytical Approaches to Blending Political Science With the Study of Energy Markets

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

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Key Points

Energy is arguably the most valuable traded commodity in the world. Unlike most other commodities, energy resources are essential for economic and military activity and therefore have unique strategic importance, especially because states vary widely in their energy resource endowment.

The social sciences, and political science, in particular, have developed advanced quantitative techniques and datasets for analyzing geopolitical and economic phenomena. Such tools carry the tremendous potential to further our understanding of global markets, especially the interactions between energy markets and political events at local, national and international levels.

The Payne Institute of the Colorado School of Mines and KAPSARC held a joint workshop, "Analytical Approaches to Blending Political Science with the Study of Energy Markets," in April 2019. The following key points highlight the day-long discussion:

- Politics at all levels affects global energy markets. Local demands and national policymaking are increasingly situated at the heart of global energy relations. Future studies should connect local- and national-level factors to the outcomes of global energy markets.

- Future analysis of politics and global energy relations should include electricity and renewable technologies in addition to traditional energy sources such as oil and gas.

- Geopolitical risks remain as relevant for global energy markets as they were in the last century. The increasing presence of pipelines and liquefied natural gas (LNG) terminals, however, has reshaped our understanding of energy dependence between exporting and importing states.

- The renewable energy transition and accelerating demand for renewable energy investments call for studies to investigate the relationship between the market for rare earth minerals and interstate relations.

- The concepts and statistical tools of political science can help inform energy market scholars and policy experts and improve their forecasting capability. Some of these techniques include collective decision-making process models, spatial event analysis and advanced maximum likelihood estimation methods.

- Social science techniques for data collection and management, such as neural networks and deep learning, support vector mechanisms, and multiple imputation, will allow scholars to study the links between political phenomena and energy markets in ways that were not possible before.

Summary

As the global energy market grows more intertwined with politics, policymakers face increasingly complex challenges. The spheres of influence of individuals, governments, and international organizations are no longer clearly demarcated. A local government can block a multinational electricity trade deal. A social media campaign can change a country's energy investment priorities. Shifts in policy and consumer preferences in one state can quickly cascade through global linkages.

The lack of effective global energy governance, and the inadequacy of local and national mechanisms in the current geopolitical landscape, is clearer than ever before. Exacerbating this uncertainty is the rising tide of nationalism and populist rulers willing to sidestep laws and institutions. The renewable energy transition further complicates the dynamics of global energy markets and their geopolitical implications. In particular, the increasing demand for rare earth minerals is reshaping relations between exporter and importer countries.

Two symmetrical issues guide most empirical studies in political science: how political phenomena affect relations between political players, and, in turn, how relations between political players shape political phenomena. Political science has developed a wide range of tools to understand these interactions at different levels (e.g., politicians, states, local governments, market players) and for various political phenomena (such as sanctions, trade deals, militarized disputes, alliances and foreign direct investment). These tools facilitate predictive analysis and help to filter out noise from complex datasets — yet many of them have not yet been systematically applied to study how political phenomena shape global energy markets and vice versa. To effectively address the questions pertinent to energy markets, these tools need to exhibit the following characteristics:

> *Account for complexity*: Global energy markets comprise many players interacting across geographic markets for numerous commodities. Methodological approaches, such as models of collective decision-making processes, vector autoregression models and models employing panel data allow analysts to account for such complexity.

> *Based on cutting edge data*: Timely, comprehensive and innovative data collection allows researchers to ask creative and relevant questions. Techniques such as neural networks, automated text mining and coding, computer assisted georeferencing, and imputation for large cross-sectional time series, among others, make possible the collection of such data at varying scope and frequency.

> *Transparent and open-source analysis*: Science is a cumulative enterprise for which a significant amount of new knowledge is obtained by applying existing tools to new questions. The transparent and open nature of the techniques developed to analyze global energy markets is key to global collaboration and cumulative progress.

Participants in the workshop demonstrated the application of various models to the following questions:

> Does importing energy sources pacify a country against its supplier in the international arena, exemplifying the use of panel data and maximum likelihood estimation?

> What may be the unintended consequences of oil embargoes on a producer state, exemplifying the use of a global vector autoregression model?

How will the debate on compliance with United States-led sanctions on Iran evolve among global players, exemplifying the use of a model of collective decision-making processes, based on a spatial agent-based model of bargaining?

How can unstructured text from news and government reports be automatically transformed into structured, quantitative and georeferenced data, exemplifying the use of automated text analysis?

Background to the Workshop

This workshop, co-hosted by KAPSARC and the Payne Institute, aimed to encourage new research that systematically looks at the relationships between energy markets and geopolitical phenomena such as sanctions, diplomatic activity, and cross-border disputes. The relevance of such issues to energy markets depends on global and domestic economic conditions, the geopolitical environment, and other factors that vary over time and space.

Currently, there is a dearth of multidisciplinary research that draws together political scientists, statisticians and econometricians, energy market specialists, energy systems modelers and others with insight into these complex phenomena. Thus, this event provided a valuable opportunity for relevant communities of experts to come together to exchange insights.

The workshop comprised four sessions. Each session began with short presentations by selected participants, followed by a roundtable discussion aimed at encouraging new insights and identifying future research directions in the areas presented. The key topics covered in the workshop were:

- Research priorities for policymakers for understanding the relationships between geopolitical phenomena and energy markets.
- Conceptualizing energy in the context of interstate relations.
- Innovative techniques for assessing the relationships between political phenomena and energy markets.
- The energy transition, materials and minerals, and the future of energy markets.

The event included contributions from international research institutes, leading universities, think tanks and other experts. It was the first in a series of workshops intended to foster an environment where practical and rigorous research ideas can be conceptualized, developed and executed.

Global Energy Markets and Security: Current Challenges

Energy is arguably the most valuable traded commodity in the world. Unlike most other commodities, energy resources are essential for economic and military activity and therefore have unique strategic importance — especially because states vary widely in their energy resource endowment. Its abundance was critical to the rise of some global powers (e.g., the United Kingdom [U.K.]) while its scarcity has led others to start wars and then decline (e.g., Imperial Japan). Intense competition between states over energy resources makes understanding how energy affects international politics critical for policymakers and market participants.

The global energy market has become increasingly intertwined with politics at the international, national and local levels. Individuals, local and national governments, and international organizations can each shape and disrupt global energy flows. This multi-tiered nature of global energy relations brings about challenges in understanding how political phenomena interact with global energy markets.

Political science has developed a wide range of methodological approaches to understand and anticipate the behavior of players at various levels and how their actions shape political phenomena. These tools facilitate predictive analysis and help to filter out noise from complex datasets, thereby offering significant insight into the future of energy markets.

The international level

Geopolitical risk is central to the outlook for energy security. Military conflicts can quickly disrupt the functioning of the global energy market, especially since a handful of geographic chokeholds — particularly the Suez Canal, the Strait of Hormuz and the Strait of Malacca — remain the primary conduits for much of the world's oil and gas trade. Recent examples of acute geopolitical risk include the threat by the Iranian government in 2019 to close the Straits of Hormuz to oil traffic, in response to the decision by the United States (U.S.) not to renew waivers of ongoing oil sanctions, as well as seizures of oil tankers.

The Hormuz and Malacca Straits pose a special risk for East Asia. More than 30% of the world's seaborne oil passes through each of these two points; 90% of oil bound for Japan traverses both these straits.

Contested territories remain a significant risk for the global oil market. Hydrocarbon exploration in the East Mediterranean and the South China Sea, for example, has pitted Turkey and China against other littoral states in their respective regions. The emergence of new transport routes is another source of tension, with powerful countries scrambling to claim pathways through the Arctic opening up as a result of climate change.

Potential disruptions to global energy value chains do not emanate only from security risks. Conventional global governance mechanisms are being challenged, most notably by the shift of the U.S., under President Donald Trump, away from multilateral institutions, and by the rise of China and its Belt and Road Initiative (BRI), which entices energy exporters to divert output into an alternative worldwide system.

The rise of renewable energy generation could also trigger conflicts over territory between neighboring states. Compared with traditional thermal power, solar power typically requires eight times more land area, with wind power requiring about 40

times more. Dormant conflicts over border areas may reignite as states lay claim to these lands to generate renewable electricity. Offshore wind farms could likewise spark maritime disputes over rights to exclusive economic zones and other ocean areas.

Recent decades have highlighted another challenge at the international level: building effective and responsive regimes for global energy governance (Van de Graaf and Colgan 2016). The most visible actions in recent years have occurred under the umbrella of the Paris Agreement and nuclear energy management (e.g., the IAEA). Similarly, the European Union has asserted its 'debundling' principle to third parties supplying energy to the European grid.

The national level

A number of states vigorously pursue innovative policies for energy efficiency and security. National campaigns and popular movements to reduce energy dependence have become commonplace, especially in the developed world. In addition to effective domestic institutions, the pursuit of national energy goals requires a high level of interstate coordination on the legal, financial, diplomatic and scientific fronts. Accordingly, interesting cooperation schemes at the international level have emerged to allow such national goals to materialize.

For instance, Germany has become a leader in the production of wind turbines, solar photovoltaics and other renewable energy technologies. The German government is actively utilizing 'soft power' tools, such as the establishment of jointly owned think tanks that focus on renewable energy research, to promote green energy adoption in potential customer countries. Other bilateral initiatives, such as the Saudi Arabia-Japan collaboration on carbon dioxide (CO2)-free hydrogen and ammonia production technologies, provide an interesting showcase of how a major energy exporter and importer can coordinate to engage in the zero-carbon industry.

The local level

Local stakeholders can also significantly impact national and international energy policy. From a security perspective, non-state actors, such as insurgents, present serious concerns and modeling their behavior has been of considerable importance to scholars and policymakers. These actors can disrupt the energy sector in a variety of ways including piracy, oil and mineral theft, illicit trade and sabotage. Cybersecurity is another area in which local players (whether firms managing cybersecurity risks or 'faceless' individuals directing cyberattacks) directly affect the stability of national energy systems.

Local politics can also directly influence global energy markets. Following the Fukushima incident, certain local players, such as the mayors of Mihama and Takahama and power companies such as the Kansai Electric Power Company (KEPCO) and Yonden, played important roles in shaping the national debate on whether to restart Japan's nuclear plants (Efird et al. 2018). The national government's eventual decision, in turn, will have important repercussions for global energy markets. In the U.S., local politics in the state of New Hampshire led to the veto of the Northern Pass project, which aimed to transfer more than 1 gigawatt of hydropower from Canada across the border to New England. Finally, public opinion is a major determinant of energy policy, especially at the local level. Public opinion has been a key factor in (the delay of) the restart of nuclear plants in Japan and the New Hampshire Site Evaluation Committee's denial of a certificate for the Northern Pass project.

Energy and Political Science: A Survey

Political science research has benefited from the analysis of the political, military and cultural traits of potentially interacting states at both individual and dyadic levels. The former considers the characteristics of a single state (such as its regime type, its level of economic development, or whether it is landlocked), while the latter compares the aspects of pairs of states (such as the relative military power of one over the other, or whether the two are allied or at war). Whether or not both states in a dyad are democratic (Russett and Oneal 2001), are similar in their cultural and domestic political institutions (Huntington 1996; Henderson and Tucker 2001) and retain similar membership to international organizations (Oneal et al. 2003) are among many dyadic factors that have been systematically studied and shown to shape interstate relations. The nature and extent of economic ties between two states is another widely examined variable that has been demonstrated to affect bilateral relations (Polachek 1980; Gelpi and Grieco 2008; Gartzke 2007).

Empirical findings on economic relations and interstate behavior

Do more economic relations between two states lead to cordial relations or conflict? This question has fueled debate since the time of ancient Greece, continuing through the medieval ages and into post-Renaissance mercantilist Europe several hundred years later (Keshk et al. 2004). The concept of economic interdependence was introduced to modern international relations (IR) literature by Immanuel Kant's *Perpetual Peace* at the turn of the nineteenth century. It became a focus of IR after the Cold War with the advent of democratic peace theory (Maoz and Russett 1993).

Scholars examining this topic can historically be grouped into three categories. Realists argue that increased economic interdependence between states leads to conflict, while liberals counter that it strengthens cooperation between states. A third camp looks beyond the realist-liberal dichotomy to ask under what specific circumstances economic interdependence creates problems or fosters cordial relations.

Scholars have long established that international trade is Pareto-optimal for participating countries — in other words, it increases the overall welfare of participants without making any worse off. Still, many realist scholars claim that more frequent economic interaction causes relations to become more adversarial, arguing that trade tends to follow the flag, makes states vulnerable to volatilities in critical supplies and hence increases the likelihood of conflict (Mastanduno 1988; Barbieri 2005). The realist position is based on the assumption of a 'security dilemma,' an essential feature of geopolitics for many IR scholars. The security dilemma posits that states are concerned with relative, rather than absolute, gains from any interaction, including trade. International trade often tends to favor one party more than the other, thereby making one party relatively stronger even though both are better off in absolute terms. In an anarchical environment, where no higher authority exists to police and sanction a belligerent state, every state must fend for itself and will strive to maximize its power relative to others. This will also make opportunistic attacks against weaker targets more likely.

In contrast, liberal democratic peace theorists assert that 'peace dividends' enlarge and strengthen the dovish camp in trading countries, leading to more cordial relations between states. This pacifying effect becomes especially potent when beneficiaries of international trade have more influence over the foreign policymaking apparatus of their respective states. Eventually, the liberal-realist debate evolved as the focus shifted from the nature of specific goods traded to economic ties alongside trade,

such as foreign direct investment (Rosecrance and Thompson 2003). Dorussen (2006), for instance, showed that the exchange of goods and resources that can otherwise be easily appropriable by force builds tensions between trading states. Trading goods that rely on high levels of technology, as well as human and organizational capital, on the other hand, brings countries closer into partnership.

Interestingly, energy interdependence has not yet been examined as a distinct phenomenon in prevailing political science literature. As the most important traded commodity in global markets, this omission was noted with interest by workshop participants. It is a significant gap, as the arrival of new technologies such as fracking and renewable energy constantly disrupt global energy trade and transform interstate relations. Before considering how this may be addressed, the workshop discussed how quantitative political science has approached the topics of energy and energy markets so far.

Energy and quantitative political science: Taking stock

An important body of literature in political science has examined how natural resource rents, and oil revenue in particular, affect the behavior of producer states. The budgetary freedom provided by natural resources can free a state from economic constraints, with both positive and negative outcomes. States are usually very reluctant to fund costly foreign policy endeavors, and war in particular, through taxes on the citizenry. When states do engage in such expensive moves, they tend to expect the duration — and therefore the cost — to be limited and victory to be very likely. Similarly, the quest for enhanced citizen welfare will encourage states to cooperate in global markets to improve their economies by enhancing international trade and attracting foreign direct investment and portfolio capital.

Income generated by natural resources relieves states from the pressure to raise taxes. In extremis, these rents may disincentivize rulers from strengthening state institutions — the so-called 'resource curse.' Michael Ross (2012) has demonstrated that rents from natural resources (and oil in particular) weaken state institutions in producer states, leading to economic instability and a higher incidence of civil conflict. Similarly, Ross and Voeten (2015) showed that "natural wealth liberates states from the economic pressures that would otherwise drive them toward [international] cooperation." Since there is often an asymmetric relationship between energy exporters and the importers (Goldthau 2008; Harsem and Claes 2013), suppliers often resort to using energy as a foreign policy tool (Smith 2008; Kramer 2009).

However, more recent studies have shown that states with high levels of resource rents are not necessarily more aggressive; rather, some of these states may prefer stable markets and production over profit from rents. It is only 'revolutionary' states, which seek to challenge regional or global status quos, that channel resource income to aggressive foreign policy behavior (Colgan 2013; Hendrix 2017). Otherwise, being a substitutable supplier — as is generally the case with oil — reduces the leverage an exporter has over its trade partners (Peksen and Peterson 2016; Kavakli, Chatagnier, and Hatipoglu 2018). Energy resources can also be a dual-edged sword: the risk of civil war increases for governments that command natural resource rents, and energy resource rents in particular (Ross 2004; De Soysa and Neumayer 2007).

Research in political science has primarily improved our understanding of how energy-related variables

and states interact at the monadic level. That is, how an individual state's internal and external policies evolve according to its energy relations. Existing studies have not sufficiently blended political science with energy markets at the dyadic level to look at bilateral relations vis-à-vis energy, especially in large-N settings (Levi 2010). Other scholars also contend that studies on energy from a political science perspective have been largely confined to security-related issues, although interest in global energy governance has surged over the last decade (Van de Graaf and Colgan 2016). While recent studies on the Paris Agreement have demonstrated how political science can enhance our understanding of climate change policies (e.g., Urpelainen and Van de Graaf 2018; Keohane and Oppenheimer 2016), other aspects of energy markets and policy remain largely untouched by political science research.

Connecting energy markets to interstate relations: Illustrating various approaches

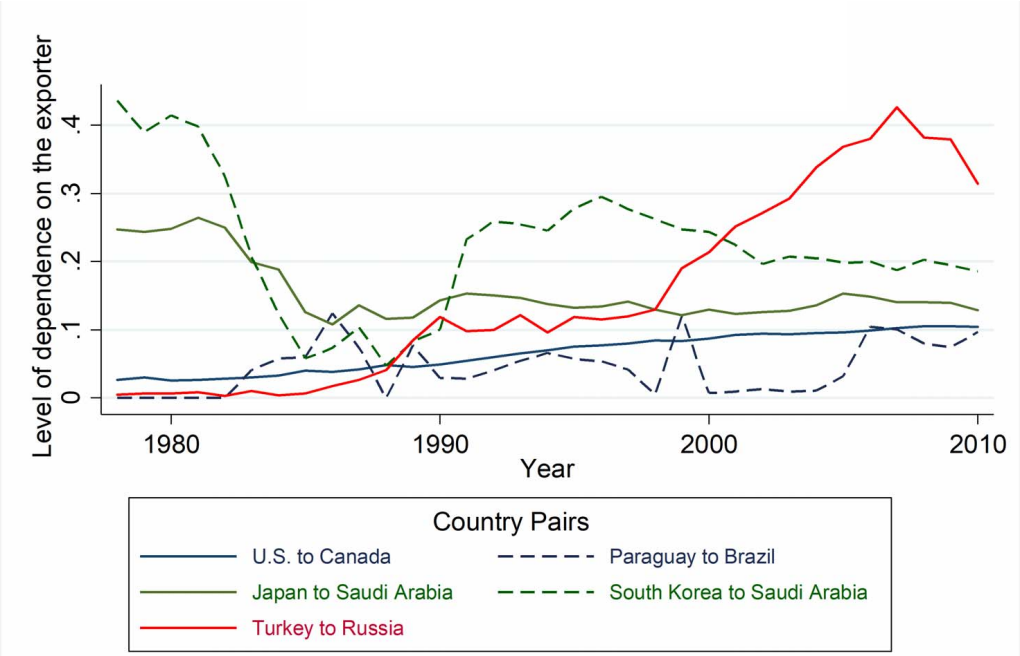
Two symmetric questions undergird studies focusing on energy and interstate relations: How do energy markets affect relations between states, and in turn, how do relations between states affect energy markets? Despite the centrality of energy to geopolitics, there is little existing quantitative analysis that causally links these two phenomena from a political science perspective. There are two primary reasons for this scarcity. First, there is a lack of systematic large-scale data collection on energy relations between states. Second, advanced models in economics and decision-making have not been adapted to address the relationship between energy markets and political phenomena. The workshop introduced techniques that can bridge this gap in multidisciplinary research. It also held discussions on how these tools could be further calibrated to suit the needs of both policymakers and academics.

How energy markets shape interstate relations: The energy dependence dataset

At the global level, systematic data collection and the availability of open source data have significant positive externalities for academics and policymakers. One very recent effort to facilitate the blending of quantitative political science into the study of energy markets is the construction of the Energy Dependence Dataset, which measures the percentage of a country's total primary energy supply that is imported from each partner exporter (Gokce and Hatipoglu 2019). The statistics are reported at the aggregate level (standardized over megajoules) and broken down by energy type (coal, oil, gas and electricity). The data currently cover the years 1978 to 2014, with a bilateral version that includes more than 500,000 country-pair (dyadic) years, and a single-country version that offers about 64,000 entries for country-years. The data have been compiled from the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), CEDIGAZ, the United Nations International Trade Statistics Database, and national statistics accounts.

Figure 1 illustrates the varying energy relations for selected country-pairs from 1978 to 2014 using the Energy Dependence Dataset, and it confirms that bilateral energy relations have changed over time. For example, U.S. dependence on Canadian energy exports steadily increased from 6% in 1978 to a peak of 15% in 2008, before being disrupted by the global financial crisis. Paraguay's energy reliance on Brazil appeared to be cyclical until 2005, after which one can observe a steady increase. The North Atlantic Treaty Organization (NATO) member Turkey

Figure 1. Levels of energy dependence over time, selected country pairs.



Source: Gokce and Hatipoglu (2019).

shows surging dependence on Russian energy following the demise of the Soviet Union in 1989, highlighting how geopolitics can impact energy trade flows. Comparing the energy relationship between Saudi Arabia and its two historically important clients in East Asia, Japan and South Korea, also reflects an interesting trend. While both countries have long been highly dependent on Saudi energy exports, South Korean imports of Saudi oil exhibited far more volatility than Japan's until the mid-2000s.

Understanding what leads to this variance and how such fluctuations impact international events is fundamental to establishing connections between geopolitical phenomena and energy markets. For example, initial analyses suggest that dependence on gas may be a stronger deterrent than dependence on oil for importers against their exporters. The Energy Dependence Dataset, soon to be available publicly, will allow further studies to empirically verify such behavior within and across country-pairs.

Connecting energy markets to political phenomena: The KAPSARC Global Oil Market and Inventories Model

Political phenomena, in turn, often disturb global energy markets. The recent U.S. decision not to renew sanctions waivers for eight customers of Iranian increased the price of crude by 3% in a single day. Of the seven drawdowns from the U.S. Strategic Petroleum Reserve since 1985, two occurred due to political events, namely the 1991 'Desert Storm' operation against Iraq and the 2011 upheavals in Libya and elsewhere in the Middle East.

The KAPSARC Global Oil Markets and Inventories Model is a powerful tool for blending quantitative political science with the study of oil markets. It is an econometric global vector autoregression (GVAR) model that links 12 commodity and financial markets across 36 countries (Considine and Aldayel 2018). The commodity variables include oil, agricultural and metal prices, and a global shipping index at the global level; oil production, oil inventories at the national level. Inflation, short- and long-term nominal interest rates, equity prices, real exchange rates and real gross domestic product are the financial variables, all at the national level. Building upon Mohaddes and Pesaran's (2017) Global Oil Markets model, KAPSARC's GVAR model utilizes quarterly data from 1979 to 2019 to simulate disturbances in the aforementioned markets, and see the resulting impact on other markets within and across states through cointegrated relationships.

To illustrate the model's application in the field of political science and energy markets, it was used to assess the potential effects of financial sanctions on an oil producing nation (Indonesia) at the national, regional and global levels. Political science has tended to treat financial and commodity sanctions as separate phenomena, assuming that each causes varying levels of pressure on the ruling elite of the targeted state. The debate over 'smart sanctions' likewise carries this implicit assumption, some arguing that financial sanctions have fewer adverse implications for the populace in general. Showing whether and how financial sanctions can spill over to commodity markets may bring a novel dimension to this ongoing discussion.

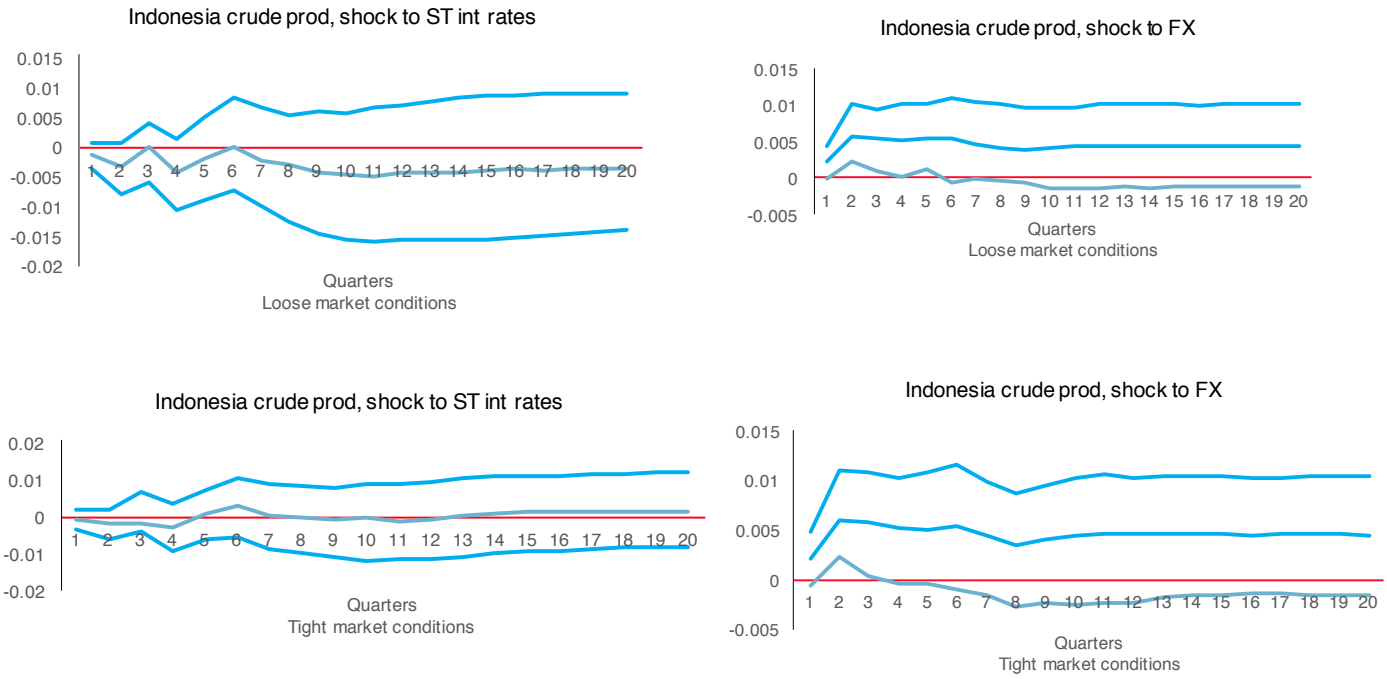
Two types of financial sanctions on the Indonesian economy were simulated using the model, by imposing, separately, a 14% depreciation of the Indonesian rupiah and a 2% increase in short-term interest rates as a shock at the start of the simulation. The model was run under scenarios for both loose and tight oil market conditions, taking Q4 2018 and Q4 2013 as the starting points, respectively.

The KAPSARC Global Oil Markets and Inventories Model's simulations rendered interesting results; some highlights are displayed in Figures 2 and 3. A depreciation in the value of the Indonesian rupiah is expected to increase oil production, especially in loose oil market conditions (about a 3.5% increase in the first year). This is likely because a depreciated rupiah motivates Indonesia to produce more for export.

The results indicate that changes in short-term interest rates do not affect Indonesian oil production but can have adverse spillover effects in the region. The hike in interest rates turned out to be costly for equity prices not only in Indonesia but also in the Philippines, which suffers a drop of 2.8% in the first year. Global oil prices (not shown) are not affected by either type of financial sanctions under loose or tight oil market conditions.

The simulation results suggest that financial sanctions can spill over to commodity markets under certain circumstances. While this insight may be obvious to policymakers, verification through robust quantitative analysis can help inform the debate on 'smart sanctions' in political science literature. The hypothetical disturbances in the case of Indonesia point to two possible unintended consequences: depreciation of the Indonesian rupiah that pushes up oil production, and an increase in Indonesia's short-term interest rates that depresses equity prices in neighboring countries. Such consequences, one may argue, would hardly be desirable for the designers of an economic sanction.

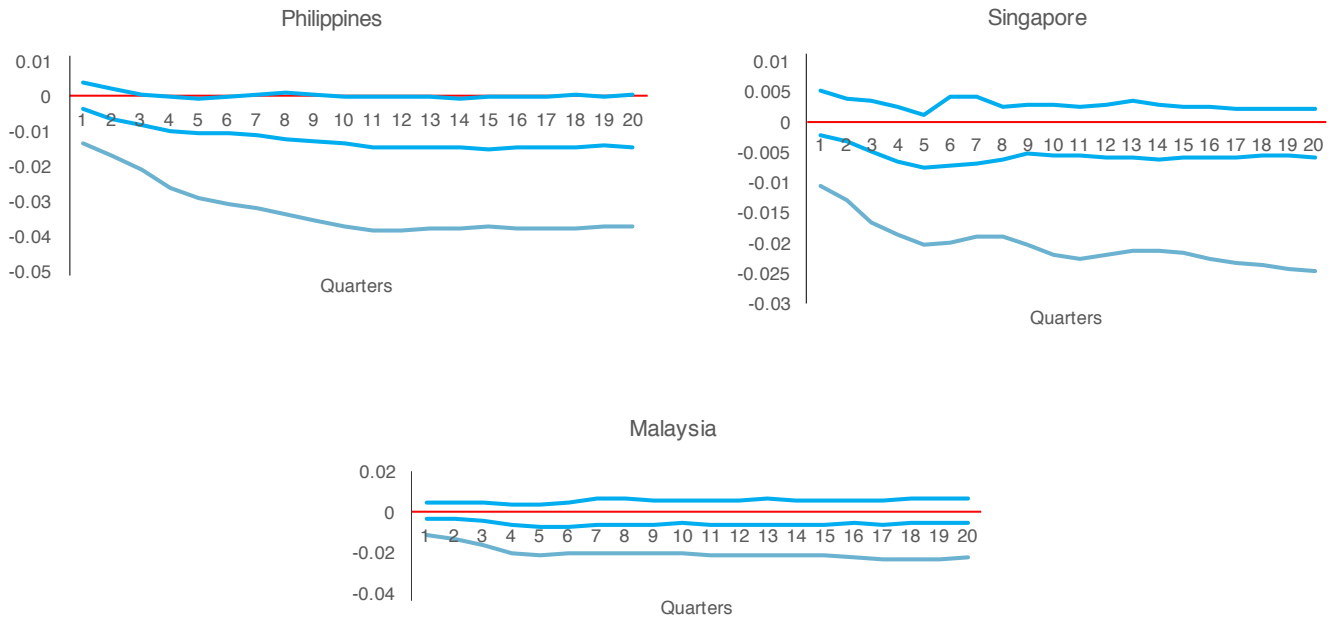
Figure 2. Indonesian oil production response to simulated financial sanctions.



Source: KAPSARC simulations.

Note: FX = foreign exchange; ST int rates = short-term interest rates. Y axes denote % deviations from baseline projections per quarter; X axes denote quarters since the imposition of the shock.

Figure 3. Spillover effects of simulated Indonesian financial sanctions on regional equity prices.



Source: KAPSARC simulations.

Note: Y axes denote % deviations from baseline projections per quarter; X axes denote quarters since the imposition of the shock.

Modeling collective decision-making processes: KTAB and compliance with sanctions on Iran

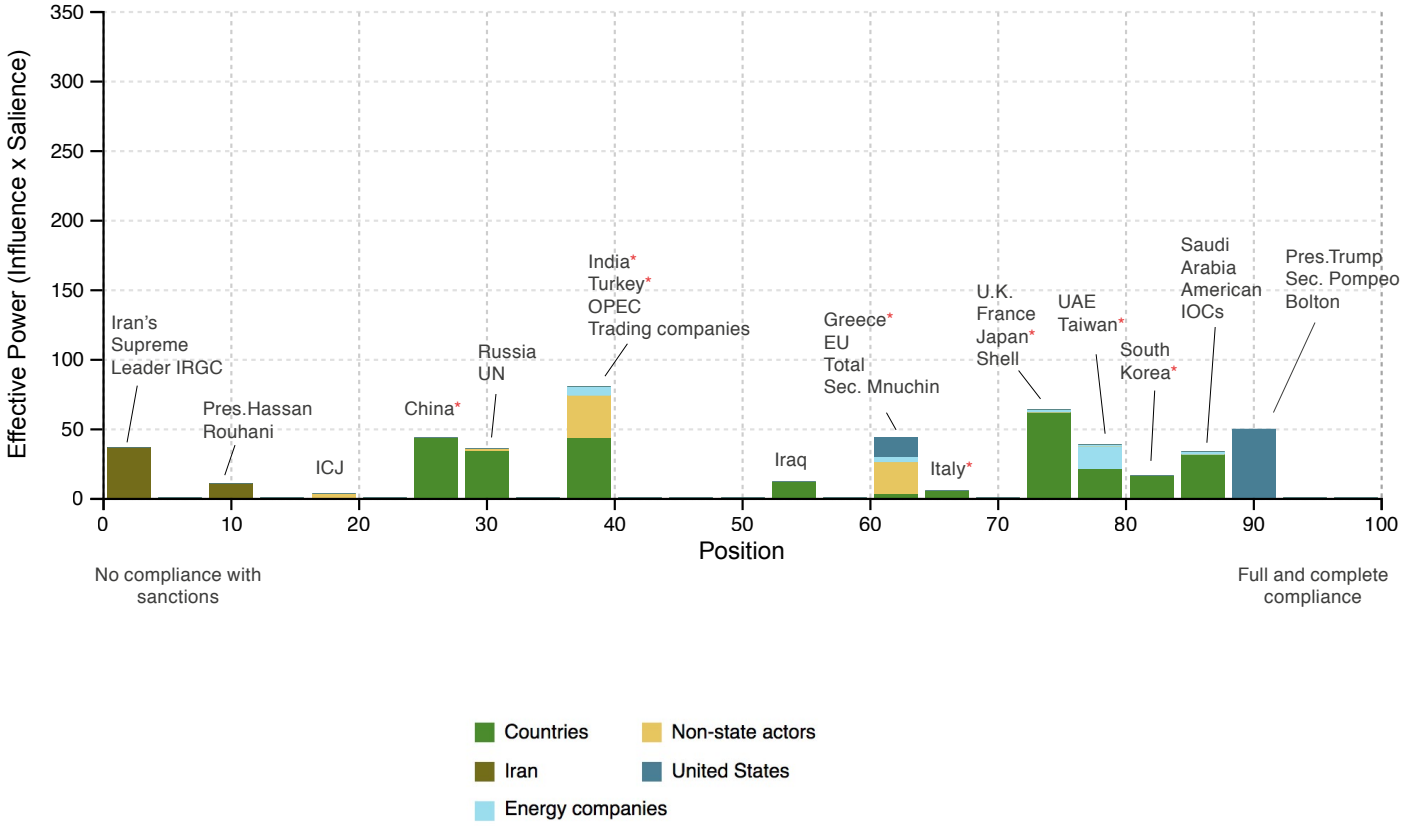
Modeling decision-making processes is another way that political science can enhance the understanding of energy markets. Policy decisions are often the result of negotiation among stakeholders that have power over and/or interests in such decisions. Political science scholars have developed various tools, from simple decision-theoretic models to agent-based simulations, to understand and anticipate the outcomes of such bargaining processes. One such recent contribution is the KAPSARC Toolkit for Behavioral Analysis (KTAB), an open source model-building platform that facilitates the systematic and rigorous analysis of collective decision-making processes (for replication purposes, all documentation, source code and papers can be found at http://www.ktab.software).

KTAB simulates collective decision-making processes (CDMPs) among a set of players (characteristically between five and 50) over a number of turns of negotiation, based on data obtained from semi-structured interviews with subject matter experts. Studies employing KTAB have analyzed topics including country-level compliance with announced nationally determined contributions (Al Quayid et al. [forthcoming]), Japan's decision to restart nuclear investments after the Fukushima accident (Efird et al. 2018), and the political feasibility of a Gulf Cooperation Council (GCC)-wide power market (Mollet et al. 2018).

The KTAB study discussed in this workshop analyzed the extent to which the international community will comply with the U.S.-led sanctions on Iran. The model represents the domestic and international political forces affecting the United States, Iran, Iranian importers and other actors that can shape countries' decisions to comply with sanctions. It simulates actors' changing views on the appropriate level of compliance, based on the evolving political pressures from various interests and centers of political power. Both the expert opinion data collection and the simulations were completed before the U.S. sanctions waivers were announced.

The initial and final positions of the actors in the bargaining process of this simulation are exhibited in Figures 4 and 5, respectively. Figure 4 maps the starting distribution of players regarding their stated preference for compliance with the sanctions, with the height of each bar showing the effective power they could apply to influence the issue. Figure 5 shows the ending distribution after KTAB simulates 24 turns of a CDMP among these players. The simulated results show the U.S. is likely to capitulate on the issue of uniform compliance. These findings suggest that U.S. decision-makers recognized that securing multilateral support for sanctions could occur at the expense of their effectiveness. Sanctions waivers offered a face-saving effort in the hope that the underlying geopolitical conditions would change over time. While the U.S. initially announced that it would not be renewing the waivers established in November 2018, and recently announced that some waivers would be extended, we have yet to see how this new round of impositions will play out.

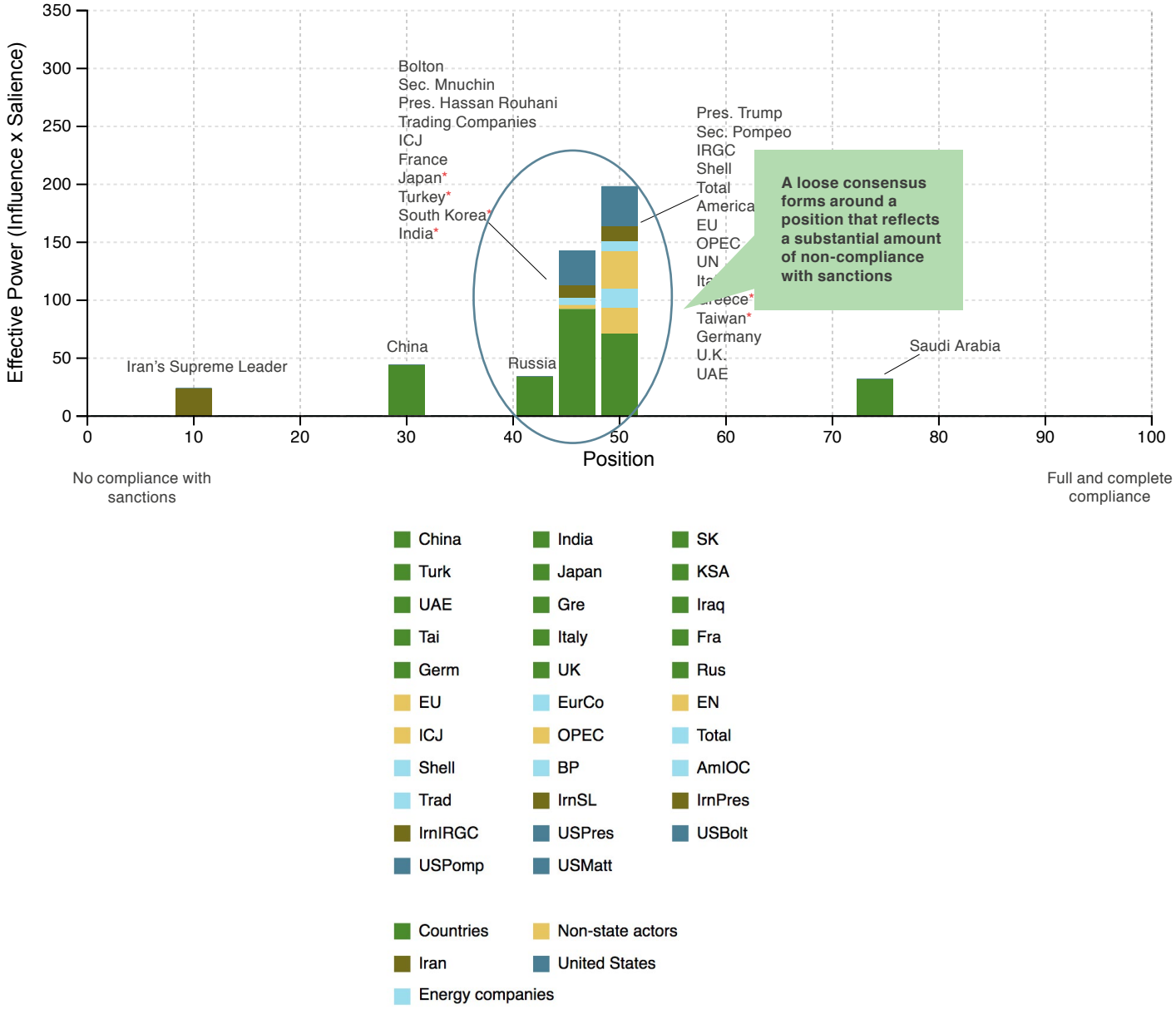
Figure 4. Start of KTAB bargaining simulation on Iran sanctions.



Source: KAPSARC simulations.

Note: Pres. = President; ICJ = International Court of Justice; UN = United Nations; Sec. = Secretary; EU = European Union; UK = United Kingdom; UAE = United Arab Emirates; IOCs = International Oil Companies; IRGC = the Islamic Revolutionary Guard Corps.

Figure 5. Result of KTAB bargaining simulation on Iran sanctions.



Source: KTAB simulation.

Note: Pres. = President; ICJ = International Court of Justice; UN = United Nations; Sec. = Secretary; EU = European Union; UK = United Kingdom; UAE = United Arab Emirates; IOCs = International Oil Companies; IRGC = the Islamic Revolutionary Guard Corps.

The Future of Energy and Geopolitics

What could be the future for research that more systematically connects energy and geopolitics? To answer this, two additional questions were addressed at the workshop. First, what fundamental changes lie ahead in energy and geopolitics? Second, how can we connect the study of these two issues? For energy, the participants mainly focused on the role that technologically critical minerals and materials will play in the renewable energy transition. For geopolitics, the blurred distinction between interstate and intrastate emerged as a recurrent topic, with a specific focus on civil conflict.

A new form of interdependence: Minerals, renewables and energy transitions

As the debate on climate change occupies an increasingly salient place on the global agenda, transitioning to clean, carbon neutral energy has become a focal point for most states. Such transition requires a secure and steady supply of rare earth elements (REE) necessary for key renewable technologies.

Materials such as lithium, cobalt, graphite and vanadium are critical to manufacturing and maintaining renewable energy products and installations; defense, space and other advanced technologies are also highly reliant on rare earth metals and minerals (Department of Energy 2011). Lithium and cobalt are key to the production of battery cells; gallium is an essential component of LED cells; neodymium and dysprosium are used in wind turbines and hybrid cars, to name only a few important uses of REE.

Current projections point to a sizeable increase in the global demand for REE in the coming decades. Alonso et al. (2012) argue that, "following a path consistent with stabilization of atmospheric CO2 at 450 ppm [parts per million]," the global demand for neodymium and dysprosium over the next 25 years may increase by seven- and 26-fold, respectively. Similarly, the demand for lithium, compared with 2017 levels, could increase by 117% to 674% by 2030, depending on the speed of the energy transition.

World REE markets have so far experienced only small supply shocks, which have not yet reached crisis levels. For example, in response to a maritime clash with Japan in 2010, China stopped exporting rare earth minerals to its eastern neighbor for two months. Cobalt production in the Democratic Republic of Congo, the world's leading exporter of the mineral, has often been a stop-and-go process because the government has had numerous political, economic and human rights-related issues with its neighbors as well as the world community. The resulting deterrence to investment has created bottlenecks throughout the global supply chain.

It is important to note that the current reliance on a limited number of producers is not due to scarcity of resources. Deposits of many rare earth minerals are widespread on Earth. For example, a 2014 parliamentary report argued that "half of the rare earths that are available for exploitation outside of China are available in Canada" (Standing Committee on Natural Resources 2014, 11). Instead, the geographical concentration of rare earth minerals production today has been a result of supply-demand equilibrium. Chinese dominance in REE markets has mostly been due to its "operational cost competitiveness" (Manchieri 2019). Excavating such minerals can be costly and heavily polluting. Many advanced countries have been reluctant to invest in rare earth mineral extraction, preferring to externalize this process to poorer countries.

Such supply gaps are risky for world trade and may produce tensions in global relations. Advanced manufacturing chains are increasingly more sensitive to interruptions in the flow of materials. Factoring in the cost of supply risks may render renewable energy projects unprofitable or commercially unfeasible. Disruptions in the transition to 'cleaner' energy at the country level may also reverberate on a global scale, potentially preventing countries from meeting their nationally determined contributions, and undermining the global carbon trading scheme.

Freeman and Bazilian (2018) also point out three distinct ways the increasing reliance on REE can trigger tensions that may escalate to military conflict. First, at the intrastate level, producer countries with weak institutions are vulnerable to insurgents capturing their resources. Second, at the international level, states may compete to establish hegemony over global 'resource commons.' Finally, supplier states may use dependency on these minerals as leverage to extract concessions from importer countries.

Future analysis of energy markets and geopolitics should incorporate the evolving importance of REE. Real time monitoring, data collection and analyses of REE data can be employed to build canonical datasets for use in international relations and international political economy. This will improve forecasting capabilities with respect to how geopolitical events affect the dynamics of REE markets, and vice versa.

The blurring of borders: The decay of the intrastate-interstate distinction

In the decades following the end of the Cold War and the 9/11 attacks, the evolving geopolitical landscape has brought about a resurgence of interest in sub-state actors, autonomous political entities and insurgent groups, and the roles they play in international relations. Dubbing this trend a 'new' kind of international relations (Kaldor 2013), scholars have adapted various canonical IR theories to further the understanding of intrastate relations, with a particular focus on civil conflict. As a result, the lines between domestic and international phenomena have blurred, and many have called for the abolishment of the formal distinction between the studies of intrastate and international relations (Henderson and Singer 2002).

Physical features and location are critical to international relations (Braithwaite 2010). Insurgents can typically withstand pressure much longer when based in the jungle or mountainous terrain (Fearon and Laitin 2003). The presence of neighboring states willing to host rebels tends to prolong civil wars (Salehyan 2007). The presence of natural resources impacts the nature of conflict among warring parties (Humphreys 2005). The borders of 'naturally' born states mimic the contours of trading-clusters within the preceding empire from which these states emerged (Schulze and Wolf 2008).

The increasing focus on physical features and geography in political science has pushed scholars to seek ever more granular location data, preferably at the level of neighborhoods and villages (Kalyvas 2006) or even homes (Bennett 2008). Systematically collecting large-scale data that link variables to increasingly small geographical units, however, represents a major obstacle to quantitative IR research. Automated mining and coding of text data offers notable potential to address this georeferencing challenge.

Text as a data source for geographic information systems: An innovative way of mapping risk

An interdisciplinary approach to energy relations and political science can benefit from innovations in the study of intrastate politics, especially its focus on geolocation. Location-specific data facilitates better prediction of conflict events near production sites, such as wells, mines, pipelines and shipping lanes. Sabotage of oil/gas pipelines and energy transmission infrastructure is often carried out in relation to intrastate conflict. Illicit oil trading meanwhile provides significant resources to warring factions and can disrupt global oil markets (Katsouris and Sayne 2013). Effectively addressing these questions requires the systematic and unbiased collection of location data related to such incidents — a tremendous undertaking.

Official reports are usually the first sources for matching an event to a geolocation. Although very useful, official reports are often incomplete and biased and need to be supplemented by other information drawn from news reports and almanacs. However, inconsistencies are common across a multiplicity of sources. The names for locations often vary due to different spellings (e.g., Kolwezi vs. Kolvezi), misspellings or variations of languages (e.g., Nicosia vs. Lefkosa), making it difficult to systematically match names with the same event.

Machine learning techniques offer a powerful tool for coding georeferenced events in very large numbers. After the machine is 'trained' on real data, it can georeference events mentioned in structured and unstructured text using fuzzy matching. Machine learning far exceeds the speed and scope of even the best human team while producing results with minimal bias. One such R-package for machine learning is freely available at http://github.com/rexdouglass/MeasuringLandscape.

Further Research Ideas Connecting Political Science and Global Energy Markets

The workshop highlighted how the techniques presented above, and other quantitative methods employed in political science, could address wide-ranging questions of concern to global energy markets. Building on the discussions held during the workshop, the following ideas were voiced as possible avenues for future research:

Energy markets are ever more sensitive to changes in the global energy policy of the U.S. The re-introduction of the No Oil Producing and Exporting Cartels Act (NOPEC) to the U.S. Congressional agenda has caused considerable uncertainty for global oil supplies in the medium-to-long term. Predicting how the NOPEC legislation proposal will play out in Congress is a difficult task. KTAB offers a formal, transparent and traceable method for simulating stakeholders' political bargaining over NOPEC within and outside of the U.S.

Oil supply security continues to be a major concern for Northeast Asian importers, particularly Japan and Korea. Oil inventories are an important tool to mitigate the effect of supply shocks and other disruptions to oil supply. Middle Eastern oil suppliers have started investing in inventory infrastructure projects in Japan and Korea. Initial GVAR analyses suggest when there is an unexpected drop in global oil production, Northeast Asian countries tend to build up inventories while Western European economies tend to draw theirs down. Further statistical analyses can help determine what underlies such discrepancies in behavior across these two markets.

Georeferencing techniques can be used to build a comprehensive database of pipeline attacks. Correlating these attacks with political variables via statistical models can increase predictive capabilities and help policymakers optimally deploy their security resources. The trans-border and security-related nature of pipelines makes automated text mining and coding especially useful for constructing such a dataset.

Various policymakers have noted the effects REE may have on geopolitics (Van de Graaf and Bond 2019; Bazilian 2018). Imputing rare-earth pricing data into the KAPSARC Global Oil Market and Inventories Model would create a pioneering model for predicting the price of various REE within a co-integrated framework that takes other commodity and financial markets into account.

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About the Workshop

KAPSARC and the Payne Institute at the Colorado School of Mines hosted the workshop, Analytical Approaches to Blending Political Science with the Study of Energy Markets, on April 9, 2019, in Golden, Colorado. The workshop was held under a modified version of the Chatham House Rule, under which participants consented to be listed below. However, none of the content in this briefing is attributable to any individual attendee.

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About the Project

This workshop took place as part of the Geopolitics and Energy Markets project, which aims to integrate insights, methods and approaches from the field of political science to better understand energy market behavior.

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