



The Economics of Energy Vulnerability



About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is an independent, non-profit research institution dedicated to researching 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

The economic vulnerability of an economy to energy disruptions is traditionally viewed through the lens of price shocks. This 'energy vulnerability' is driven by the energy mix, the infrastructure and the supply chain resilience that an economy enjoys.

- Globally, the energy mix appears to be determined by the relative costs of fuels.
- Regionally, the mix may be distorted by policies addressing security, environmental, economic and other social aspects.
- Such policies may create economic vulnerabilities to the same extent as price shocks.
- Policies designed to stabilize energy prices rather than to insulate an economy from price volatility may, ironically, lead to greater swings in prices in the long-term. As technology and regulation change the relative competitiveness of energy sources, stabilization mechanisms may create unsustainable imbalances—creating even greater hardship when they unwind.

Summary for Policymakers

The price of crude oil halved in six months from July 2014 to January 2015 with differing impacts on the world's various economies—improving the economic expectations of energy importers while reducing the rents of exporters. This kind of energy shock does not lend itself well to discussions of energy security, which is normally focused on risks of disruptions to supplies, seen through the eyes of consumers. KAPSARC has kicked off a new Energy Workshop Series exploring the economics of energy vulnerability and extending the discussion from the impacts of disruption to include:

- the impacts of volatility;
- the drivers of the energy mix; and

- how decisions on the energy mix shape a country's economic vulnerability.

Energy markets are characterized by episodes of extreme volatility in prices, such as occurred in the second half of 2014. These episodes are a source of macroeconomic uncertainty that can harm economic activity in the short-term and medium-term. From this perspective, a reduction in the volatility of energy prices might be considered as a positive state of affairs. However, policies that seek to reduce the volatility of oil prices may prove counterproductive, introducing moral hazard and potentially leading to 'reckless' market behavior—suggestions of an 'OPEC put' in the oil markets turned out to be wide of the mark.

It is difficult to define a stable equilibrium for energy prices. There are continuous changes in the costs of equipment and services, constant modifications in policies and regulations around the world and endless geopolitical instabilities. What seems like the 'right' price today will certainly be wrong in the near future. The 'right' price may only be evident with the benefit of hindsight. In other words, energy prices are intrinsically volatile.

Reducing the energy vulnerability of a country is not easy. Any significant shift of the energy mix requires long lead-time investments, making quick adjustments difficult to implement. In any case, policymakers respond to price volatility by shaping the energy mix—at least in part. Energy policy shapes the energy mix by seeking to balance energy security, environmental, economic and socio-political considerations relating to each source of energy. This implies that both prices and policies shape the energy mix. As a consequence, the vulnerability of the economy to sharp shifts in energy prices is not only the result of market forces, but also of the policies implemented. In other words, policies can create economic vulnerabilities in consumer markets in the same way as events in producer markets can cause energy security concerns.



Background to the Workshop

KAPSARC is researching the factors influencing energy vulnerability and hosted the first in a series of workshops on the economics of energy vulnerability, held on March 11th, 2015 at the KAPSARC campus in Riyadh, Saudi Arabia.

The perceived energy vulnerability of an economy is shaped by factors including sharp shifts in energy prices, uncertainty of physical supply or confidence in future energy demand. Sharp price increases typically reduce the growth of economies that are highly dependent on energy imports, reversing any current account surplus and reducing reserves of hard currencies. Such sharp increases may occur because of a tangible disruption to physical supplies, by acts of war, natural disasters or political decisions by producers or trans-shippers of energy commodities. By contrast, producer economies may be vulnerable to technological advances that enable a sustained increase in the supply of hydrocarbons around the world by rendering more reserves economically viable. The consequences of a resulting fall in prices may be the reversal of budget surpluses and potentially even a trade deficit in some circumstances.

Energy vulnerability is a multifaceted concept that is shaped by many drivers and influenced by global circumstances. A number of respected institutions have developed tools and models to assess the resilience of the energy system to various shocks and KAPSARC's work focuses on the role of the energy mix and its key drivers. These vary from the relative price of fuels and the cost of technologies, to national energy policies aimed at reducing pollution, strengthening national industries and addressing the risk of disruptions, among other drivers. However, there is no simple 'one-size-fits-all' answer.

International trade relations between governments, preferential treatment for domestic energy production and the aspiration for 'energy independence' play a role in shaping policies and the energy mix. To understand the dynamics of strategic

decision-making as it affects a country's energy policy, there is value in separating the concept of economic vulnerability to energy shocks from the more widely described phenomenon of energy security.

Price Volatility versus Physical Disruption

Severe, long-lasting intentional disruptions of energy supplies are very rare. Despite the abundant geopolitical risks confronting oil markets, no acute deliberate disruption has occurred during the past 30 years. However, this does not mean that energy markets are therefore risk free. Physical security of supply and physical security of demand cannot be assumed to be synonymous with energy price stability. There seems to be more value in separating the discussion into at least two layers:

- Complete unavailability of all or part of an expected supply. In this situation, there is no price that can be paid to secure replacement supplies in the short-term or, perhaps, even the medium-term. Planning for this type of extreme situation is personified by institutions such as the International Energy Agency (IEA), among others, and is typically described as 'energy security'.
- Disruptions that drive prices up to levels that destroy demand or drive prices down to levels that undermine continuing investment in maintaining and growing supply. The mismatch in timeframes for supply and demand to rebalance (and indeed the long lead times for most additions to energy supply) contribute to the 'bullwhip' effect that creates periods of price volatility. The uncertainties and direct costs resulting from such volatility might best be described as 'energy vulnerability'.

Oil and, to a greater or lesser extent, other energy markets experience episodes of extreme volatility in prices. These episodes create uncertainty, with repercussions on economic activity, at least in the short-term to medium-term.



The volatility that really matters is the one that changes the decisions of the investors.

The impact of energy shocks on the rest of the economy can be difficult to assess. The recent decline in oil prices is an example of such unpredictability. In general terms, economists expect a sharp decline in oil prices to be positive (and a sharp rise to be negative) for global economic activity. However, during the recent nine month decline, as of March 2015, even a 50% reduction in crude oil prices has not prevented the International Monetary Fund (IMF) twice reducing its forecast for global growth in 2015. Similarly, the run-up in prices a decade ago did not appear to derail global economic growth at the time. It may depend on the extent to which weak economic growth slows demand and/or strong supply growth overwhelms demand. The underlying context to a price shock matters.

Severe changes in market prices impact economies through two different channels:

- The first is reflected as an income transfer between importing and exporting countries—a demand-side effect. The results of a decrease or an increase in crude oil prices may be asymmetric in their impact on economic activity. A sharp increase in oil prices tends to harm the economic activity of importing countries, but a sharp decrease in oil prices does not necessarily yield a significant economic stimulus. Conversely, exporting countries, at least for advanced diversified economies, do not always appear to receive a stimulus from rising prices and, particularly in economies where government spending makes up a large proportion, experience economic slowdowns unless able to draw upon substantial accumulated wealth.

- The second channel is a supply-side effect. The extent of its economic impact depends on the composition of the energy mix and on the structure of the economy in question. Countries with a high share of the specific fuel suffering disruption in their energy mix tend to benefit/lose more from large decrease/increase in prices. Countries with higher energy productivity are less affected by price fluctuations. In each case, the extent to which energy prices feed into the costs of goods and services is the key factor driving the supply-side effect.

At first glance, price stability might appear to be a valuable feature of energy and collaboration between producing and consuming countries to reduce price volatility. This perspective would hold that volatility of prices does not send the right ‘market signal’ to investors and that the uncertainty results in less productive investment in the economy than would otherwise occur. Energy is a critical input for economic activity and excessive volatility creates a long-lasting instability that can harm both consumers and producers.

An alternative view is that prices send a signal for appropriate allocation and management of resources. Low prices are usually indicators of a relative abundance of a resource, leading to less investment in new supply, and high prices encourage investment to plug future market gaps. The ‘right’ price is only evident with the benefit of hindsight and agreeing on and defending the ‘wrong’ price ultimately costs more than allowing the market to allocate resources.

From a financial perspective, a current risk can be interpreted as a potential future cost. In that context, a reduction in the risks associated with an energy system would generate cost reductions, higher expected profitability, an increase in investments and prevent energy shocks. Nevertheless, if price volatility is significantly reduced, producers and consumers might lose the sense of uncertainty, creating some sort of moral hazard and potentially



leading to reckless market behavior. Stability of prices may lead to a removal of price signaling that is important for the sustainable functioning of markets the world over.

It has so far proved impossible to define a long-term equilibrium price for oil, natural gas or coal in any circumstances where the buyers and sellers are not the same bodies. The integrated major oil companies arguably presided over the longest period of oil price stability in history. However, many of the owners of the oil resources eventually decided that the cost to them, in terms of lost revenues, was too much and OPEC was born. Energy markets are subject to continuous changes in the cost of equipment and services. There are constant modifications to policies and regulations governing supply and demand around the world. It would appear that energy prices are intrinsically volatile.

Price risk is an important instrument that favors greater efficiency. It makes producers seek capital costs reductions and consumers invest in more efficient equipment. They adjust their behavior accordingly.

The deeper integration among energy markets and financial markets is also changing the way energy prices are set. This arises both from transparency of real-time price formation (or near real-time price reporting) and from the liquidity of such markets that typically exceed the value of the underlying commodity by an order of magnitude. For example, the New York Mercantile Exchange trading volume for natural gas is around 30 times larger than physical trade. It is not clear if greater trading moves the price 'away from fundamentals' or, alternatively, if this is beneficial because of the liquidity it creates, generating a better reflection of the markets' true standing.

Policy Responses to Energy Vulnerability

What are the mechanisms to manage risks and volatility of prices? How can policymakers respond to energy vulnerability? These questions can be tackled on three simultaneous levels:

- The first can occur through high-level policies that include the management of energy demand, efforts to increase energy efficiency and an active policy to diversify the fuel and technology mix in an economy.
- The second aims to guarantee the supply of fuels, both for direct consumption and for electricity generation, along with adequate network capabilities.
- The third level is purely operational. It includes emergency preparedness, coordination and communication, training and capability building, and monitoring performance indicators.

Energy policies do indeed shape the energy mix. Prices of oil, natural gas and coal can vary between regions, but these differences in prices do not, on their own, explain the disparity in countries' energy mixes. Indeed, governments guide the energy mix by taking into consideration other factors including energy security, environmental, economic, and socio-political concerns in relation to each source of energy and its weight in the overall energy mix.

Despite the critical influence of policies, energy prices are another major driver of the energy mix. However, the extent varies according to the geographical scale considered. Relative prices of energy sources are well correlated with the evolution of the global fossil fuel energy mix in the medium term. Not surprisingly, the same approach yields less accurate results for the European Union and, to lesser extent, for the U.S. These results suggest that policies have significant influence on the energy mix



at national level and that the main focus of policy in these developed markets is security and environmental rather than purely economic. As such, the vulnerability of the economy to sharp changes in energy prices is not only the result of market forces, but also of the policies implemented. It can be argued that policies can and do create vulnerability, just as much as prices.

The oil price is the mother of all energy prices.

A country's energy mix reacts very little in the short run to sharp changes in prices, due to technical and economic constraints on switching. The energy sector is capital intensive and characterized by long lead-time investments, making it hard to implement changes of the energy mix in the short-term. Economic agents appear to react more intensively to moderate secular shifts in prices than to sharp short-term volatility.

Crude oil has traditionally been considered as the foremost source of potential shocks and was commonly associated with macroeconomic disruptions. Nevertheless, there is high correlation among all prices of fossil fuels, indicating that natural gas prices and coal prices tend to move in parallel with oil prices. In some cases, natural gas and coal price trends decouple from oil, leading them also to play a potentially significant role as sources of future energy instability.

The recent increases in the supply of unconventional shale gas in the U.S., accompanied by a decrease in prices, has led to a rebalancing of the U.S. energy mix in favor of natural gas. This switch was driven by the improved competitiveness of natural gas versus coal and has, perhaps coincidentally, allowed greater weight to be afforded to environmental concerns.

Can the increasing use of domestic natural gas in the U.S. energy mix reduce economic vulnerability?

The answer is not that straightforward. Despite natural gas being produced domestically and from geographically diversified basins across U.S. increasing security of supply energy vulnerability is not so easily tamed. The 'excessive' dependence on natural gas can exacerbate regional price spikes at peak times, particularly if there are infrastructure constraints or extreme weather circumstances. For example, in early 2014 the differential in New York City between natural gas and fuel oil costs reached a record high of \$816/MWh while the same differential was only \$464/MWh in Boston.

Can We Measure Energy Vulnerability?

It can be tempting to believe that energy security and energy vulnerability can be quantified and 'priced' to inform investment decisions that reduce these exposures. Some have developed indices, trying to identify vulnerabilities and quantify energy security for countries—at least in relative terms. These approaches identify different sources of risk, in particular, those derived from the economic structure (such as energy trade patterns, energy intensity, diversification of energy mix, etc), and from the institutional and political environment and, even, from social factors.

It is dangerous to rely security of supply on mechanical data.

Diversification of energy sources and suppliers, buildup of strategic petroleum reserves, cybersecurity, regional grid interconnections and local production of energy are all mechanisms to protect a country from risks. However, all these mechanisms incur extra costs, leading to the question of how much a nation is willing to pay to 'insure' against these risks. Reducing the energy vulnerability of a country requires long lead-time investments and quick adjustments are hard to implement. In fact, the inelasticity of the energy mix



to sharp changes in relative prices of fuels is an intrinsic source of weakness of any energy system.

Ultimately, it may be possible to quantify the costs and exposures for specific configurations in specific countries but there is no simple heuristic that allows a general solution. It is hard to go beyond the truism that “greater diversity in energy sources and delivery systems is better than over-concentration in any one fuel or technology”. However, this does not prevent development of a general framework for analyzing the specifics of individual energy systems and the economies they support. This is the thrust of KAPSARC’s future research in this area.

Conclusions

Energy security may be a little like nuclear power. Complete disruptions or serious accidents are very rare but the consequences are catastrophic if they occur. Stakeholders tend to take a precautionary approach and potentially overpay to protect themselves from the consequences. However, energy

vulnerability is a concept that allows a less ‘emotional’ response to concerns about the reliability (and therefore volatility) of energy systems and the fuel mix that results from the overlay of policy on underlying relative prices.

The emotional response to price volatility is to seek stability that will ‘de-risk’ investments and ensure the high levels of both supply and demand that would result. But the long lead-times that characterize major energy infrastructure projects are antithetical to such stability. Indeed, the moral hazard introduced by the belief that any market participant is implicitly underwriting the potential recklessness of other market participants could be more damaging in the long-term.

Measures of energy vulnerability are hard to generalize, but a framework to identify which factors need to be incorporated into a quantitative analysis of the costs of energy vulnerability would be valuable to individual economies seeking to understand their exposures.



About the Workshop

The workshop was attended by energy security experts from academia, government, multilateral and non-governmental organizations. It was conducted on the basis that the discussions could be reported on a non-attribution basis. Participants included:

Samer AlAshgar – President, KAPSARC, Saudi Arabia

Christof van Agt – Senior Energy Analyst, International Energy Forum, Saudi Arabia

Hisham Akhonbay – Collaboration Specialist, KAPSARC, Saudi Arabia

Omar Al-Ubaydli – Director of International Relations & Geopolitics Program (DERASAT), Bahrain

Rabah Arezki – Head of Commodities Research, International Monetary Fund, USA

Vipin Arora – Economist, Energy Information Administration (EIA), USA

Tarek Atallah – Senior Research Analyst, KAPSARC, Saudi Arabia

Shahad AlBardi – Research Analyst, KAPSARC, Saudi Arabia

Jason Bordoff – Director, Center on Global Energy Policy, Columbia University, USA

Jorge Blazquez – Research Fellow, KAPSARC, Saudi Arabia

Gonzalo Escribano – Director, Real Instituto Elcano, Spain

Bassam Fattouh – Director, Oxford Institute for Energy Studies, United Kingdom

Christopher Gotch – Head of Economic and Energy Section, British Embassy Riyadh, Saudi Arabia

Lawrence Haar – Visiting Research Fellow, KAPSARC, Saudi Arabia

David Hobbs – Head of Research, KAPSARC, Saudi Arabia

Ana Maria Herrera – Associate Professor, University of Kentucky, USA

Walid Khadduri – Former Executive Editor, Middle East Economic Survey (MEES), Cyprus

Glada Lahn – Senior Research Fellow, Chatham House, United Kingdom

Michael Levi – Director, Council on Foreign Relations, USA

Giacomo Luciani – Professor, Institut de hautes études internationales et du développement (IHEID), Switzerland

Ceyhun Mahmudlu – Director of the Center for Security and Energy Research, Qafqaz University, Azerbaijan

Roula Majdalani – Director, UN Economic and Social Commission for Western Asia (ESCWA), Lebanon

Tatiana Mitrova – Head of Oil and Gas Department, Energy Research Institute, Russian Academy of Sciences, Russia

Majid Al-Moneef – Secretary General of Supreme Economic Council, Saudi Arabia

Carole Nakhle – Associate Lecturer, University of Surrey, United Kingdom

Øystein Noreng – Professor, BI Norwegian Business School, Norway



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Bill Farren-Price – CEO, Petroleum Policy Intelligence, United Kingdom

Nasser Al-Qahtani – Deputy Governor, Electricity and Co-Generation Regulatory Authority (ECRA), Saudi Arabia

Al Hassan Al Samaa – Director, Ministry of Water and Electricity, Saudi Arabia

Robert Tromop – Former Head of Energy Efficiency, International Energy Agency, New Zealand

Jean-Arnold Vinois – Senior Advisor, Notre Europe Jacques Delors Institute, Belgium

Jörg Wojahn – Counsellor, European Union Delegation, Saudi Arabia

Hongwei Yang – Division Chief, Institute of Energy Research, Academy of Macroeconomic Research (AMR), China

Martin Young – Head of Emergency Policy Division, International Energy Agency (IEA), France



Notes

About the team



Tarek Atallah is a Senior Research Analyst evaluating energy productivity investments, economics of energy vulnerability, and the effect of climate on energy consumption patterns.



Baltasar Mazano is a Visiting Fellow at KAPSARC. He has a PhD in economics from Universidad Complutense de Madrid.



Jorge Blazquez is a Research Fellow specialising in energy and economics. He has a PhD in macroeconomics from Universidad Complutense de Madrid.

About KAPSARC's Research on Energy Vulnerability

KAPSARC's research on energy vulnerability looks at energy shocks and disruptions from the perspective of both exporting and importing economies. Our objective is to understand what are the macroeconomic fundamentals that increase the resilience of an economy to energy shocks and, in particular, the role of the energy mix in reducing vulnerability. This will lead to an analysis of policies that enhance the resilience of economies to energy shocks.