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RESEARCH PAPER

# Shale Oil: On the Cusp of an Energy Revolution?

Zoheir Hamedi | March 2013

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Series: Case Analysis

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# Introduction

Since the beginning of the industrial revolution in the 18th century, fossil fuels—first coal, and then oil and gas—have become the world's principal energy source, the engine of economic activity, and a pillar of global growth. Gaining access to and controlling energy sources has become an indispensable necessity in the race for survival and progress; thus, the production of energy has become one of the most important human activities in the modern world. It is now a commonplace idea that energy, and the control of energy-producing technologies, has been the key to civilizational advancement. The historical development of energy sources and technologies has passed from animal and human muscle power, to natural sources, such as water and wind, to coal and coal-powered steam, and, finally, to oil in the early 20th century. In less than three decades, the global energy regime switched to using oil as the world's main energy source, primarily because of its low production cost and its liquid nature, which facilitates its production and transport, making it a vital commodity.

Prior to the introduction of oil into the global energy system, humanity was not concerned whether or not sufficient energy reserves were available to support global demand. Such concerns have risen sharply since the appearance of new emerging economies, such as China and India; additionally, oil has finite reserves, is a non-renewable energy source, and has an extremely elevated rate of consumption that vastly exceeds nature's rate of oil production.

The oil industry's early history was marked by the discovery of the largest reserves of crude oil in specific geographic locations—primarily, the Middle East and Latin America—by Western companies based in Western Europe and the US. Given the present role of oil in the world economy, the question of access to energy sources and establishing control over them is a strategic matter for all countries, strongly influencing their economic and international policies.

Currently, and for many years to come, there is no objective reason to fear for the availability of energy sources to satisfy global demand. This was reconfirmed by the 2012 annual International Energy Association (IEA) report on the future of energy in the world. The report stated that there are sufficient energy reserves to satisfy the projected global demand for energy until 2035 and beyond. However, these conclusions are dependent upon the truth of the report's assumptions regarding the future price of

energy and developments in extraction technologies.[1] Fossil fuel reserves, including oil, gas, and coal, are available in quantities capable of fulfilling the global demand for energy for decades to come. This is especially true regarding coal. Proven coal reserves exceed the combined global reserves of oil and gas, with the ability to power the international economy for 132 years—based on 2011 production levels.[2] On the other hand, global proven natural gas reserves—half of which are concentrated in just three countries: Russia, Iran, and Qatar—are capable of fulfilling the projected global gas demand, with combined proven reserves of over 232 billion square feet of natural gas.[3]

Globally, oil reserves should be able to supply global demand for 55 years based on 2011 production rates. Importantly, OPEC producers alone represent 71 percent of the proven oil reserves around the world.[4] All available data on proven conventional oil reserves show that there are no objective reasons to worry about potential supply shortages. In addition, more than 70 percent of the increases in the proven global oil reserves since the year 2000 have originated from revisions of data on existing oil fields, a process known as "reserves growth".[5] A mere 30 percent of new oil reserves is attributed to new discoveries.[6]

Moreover, the global oil sector has witnessed an unprecedented level of investment in the domain of oil exploration and production since 2003, reaching USD 1.5 trillion between 2010 and 2012 alone. These investments are capable of increasing the production capacity in most oil-producing countries in the coming years.[7] Notably, in the medium and long term, recoverable fossil fuel resources are much larger than proven reserves, and with the changing conditions of the global energy market and advancement in exploration and production technologies, a large share of these resources have been included in the "proven reserves" category.[8]

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[1] IEA, *World Energy Outlook,* 63.
[2] Ibid.
[3] Ibid.
[4] Ibid.
[5] Reserves growth is defined as the estimated increases in crude oil, natural gas, and natural gas liquids that can be added to existing reserves through expansion, revision, and recovery enhancement technologies, in addition to discovering new oil layers and oil-bearing formations connected to main oil reservoirs. This refers to a revision of the size of previously discovered reservoirs, rather than new discoveries. For further information, see Maugeri, *Oil: The Next Revolution*, iii.
[6] IEA, *World Energy Outlook,* 98.
[7] Maugeri, *Oil: The Next Revolution,* 2.
[8] This specifically refers to large quantities of unconventional oil and gas reserves that are available in many parts of the world, as evidenced by the American experience with shale gas.

Though the production costs of these new forms of oil and gas deposits will doubtlessly be higher than those of conventional resources, the exhaustion of conventional reserves will likely force energy companies to seek new sources that require a more complex process of exploration and production. However, this cost will decrease over time and with the expansion of energy projects, as is the case with all investments in new domains and technologies, bearing a high cost initially before gradually decreasing. Even so, the cost of producing high-quality oil and gas from unconventional sources will never be as low as that of conventional oil and gas.

In developing its productive capacity of shale oil and gas, the US, offers a unique experience that might redraw the global energy map, especially if it is reproduced in other parts of the world. These developments are attributed to technological breakthroughs in the production of new types of oil and gas that are considered unconventional, such as shale gas; these breakthroughs may constitute a qualitative leap in the long-run production capacity of shale oil and oil sands in the US.

This paper focuses on this new trend in global energy, and examines its influence on oil prices in the international markets, as well as its long-run economic, political, and geostrategic implications for the Gulf Cooperation Council (GCC) states. This is the first academic study that examines the potential repercussions of the shale oil revolution on the economies of oil-exporting Arab countries, with a special focus on the GCC countries. The paper also presents a price-collapse scenario that will occur as a result of the US' shale oil revolution and the increasing global role of unconventional energy sources. This scenario is inspired by the "oil bust" model that took place during the mid-1980s because the causes for both are arguably the same, demonstrating that a new collapse in oil prices is probable.

The objective behind this paper is not to predict the future, but to attempt to shed light on it based on a "scenario methodology"—a general scenario method has been adopted by examining the main factors affecting the energy system and oil prices in the future. In this regard, there have been several consistent attempts by private and state owned companies to predict the future of the energy market using minute and complex economic models. However, international energy expert Jean-Marie Chevalier asserts that despite the existence of these sophisticated analytic tools, predicting the behavior of the oil markets remains an impossible task. All of the predictive models that have been formulated have mistaken the size of the oil and gas reserves, the cost of their extraction, the evolution of pricing, and the global levels of energy demand, as well as other factors affecting the energy markets in general and the oil and gas market in

particular.[9] Consequently, a tendency has developed to rely on a "scenario methodology," which has been successfully applied in the energy domain by Shell since the early 1970s.[10] This method is one of the main tools used to conduct predictive studies of the medium and long term, which is particularly important for the purposes of strategic planning by companies, both public and private. The scenario method considers different visions of potential situations, seeking to objectively focus on the dynamics and the indices that can shape the critical junctures in the evolution of the energy system. The objective is less about predicting the future than it is about clarifying the prospective characteristics of the energy market and preparing for the unexpected. In other words, this is a tool composed of a mix between predictable and deterministic elements that cannot be accurately predicted. Herein lies the importance of the scenario method—its capability to surpass mental, cultural, political, and organizational limitations that restrict creative thought. In this way, this method is a suitable tool for uncovering the early signs of shifts and changes and their repercussions on the energy system, as well as permitting scientists to elaborate on precautionary measures and adopt changes before it is too late. The formulation of scenarios relies on a collective effort to identify the issues that may raise concerns or risks and the potential opportunities that may present themselves to an institution, state, or group of countries. Governmental and non-governmental organizations, such as the International Energy Agency, which issues an annual report on the future of global energy, often utilize the scenario method in planning their future.

All scenarios involve a significant margin of error because they are based on a complex sample of factors that are considered most influential, such as the technical data on reserves, production levels, technology, the scale and quality of the infrastructure, and the cost, addition to political, security, and economic factors. Nevertheless, no matter how comprehensive the list of factors, there is always the possibility that other factors may emerge that had not been taken into account.

## The Changing Oil Map

During the past decade, because of its limited nature, many have voiced their concerns regarding both oil depletion and an increase in global consumption. These fears have led to a considerable rise in the price of oil in international markets, and have gone hand in

[9] Chevalier, *Les Grandes Batailles de l'Energie*, 25.
[10] Ibid.

hand with a number of political crises in several oil-producing countries, such as the US invasion of Iraq in 2003. At the same time, global warming, which is mainly attributed to the CO2 emissions resulting from the human consumption of fossil fuels, has added to the levels of concern. As a result, decision makers, researchers, and companies have focused their efforts on finding alternatives to fossil fuels, particularly oil, such as clean, renewable sources of energy that do not harm the environment. Global interest in new and renewable forms of energy has also increased due to the high price of oil. The rise in oil prices, which began in 2000, coincided with this trend, both of which have encouraged energy companies to seek other forms of oil and gas that are available in very large quantities—unconventional oil and gas—though they have an extremely high cost of production.

### Existing forms of Oil

Oil is a dense liquid that is found in the upper layer of the earth's crust and is composed of a complex mixture of hydrocarbons; its appearance, composition, and purity vary widely depending on its origin. Oil and its derivatives are used to generate electricity and to fuel various means of transportation. Over half of the total global oil consumption goes to the transportation sector, a percentage that is expected to increase in the coming decades.[11] Oil is also the main feedstock for many chemical products, including fertilizers, plastics, and various forms of textiles.

The Society of Petroleum Engineers defines traditional crude oil as oil that is found in a liquid state that can flow naturally.[12] This means that oil and gas produced through a well should be in a geological formation that has the characteristics of a conventional geological reservoir. The pressure contained within this reservoir permits the liquids and the gas contained therein to flow easily to the surface. In contrast, the production of unconventional oil and gas takes place under different conditions, either because the geological formation that bears the liquids has low permeability, or because these liquids have a density that is close to, or less than, that of water, requiring different methods of production, transportation, or refining.

The oil industry classifies crude oil according to its relative density or viscosity (light, medium, heavy, or extra heavy). The refining industry also focuses on the level of sulfur in oil, classifying types of crude oil into "sweet," when it features a low level of sulfur, and

[11] IEA, *World Energy Outlook 2012,* 88.
[12] See http://www.spe.org/glossary/wiki/doku.php/terms:conventional_crude_oil.

"sour," when its sulfur content is high. The refining of crude oil that is rich in sulfur requires refineries that are especially equipped for this process in order to extract high-quality petroleum products.

The US Energy Information Administration (EIA) divides unconventional oil into four categories: heavy oil, extra-heavy oil, bitumen, and shale oil.[13] Some analysts argue that oil produced through gas-to-liquid (GTL) or coal-to-liquid (CTL) processes is also a form of unconventional oil.[14]

The standards established by the American Petroleum Institute (API) are those generally used to gauge the specific density of oil and measure the relative weight of petroleum liquids compared to water. If oil has an API that is higher than 10, it is lighter than water and can flow on the surface of water; when oil's API is lower than 10, it is heavier than water and is likely to sink. There is a direct inverse relationship between oil's specific density and its API level: the higher the specific density, the lower the API. The oil industry classifies oil types into light oil (with an API lower than 31.1), and medium oil (with an API between 22.3 and 31.1), heavy oil (with an API lower than 22.3), and extra-heavy oil (with an API lower than 10). The density of oil, then, indicates its distillate content.

Oil viscosity, on the other hand, is considered to be the most important characteristic in the oil industry because it indicates the ease with which the oil will flow from its reservoirs, thereby determining the extraction method. Based on this, high viscosity oil is classified as extra-heavy and oil with extremely high viscosity is classified as bitumen, which is extremely hard to extract using conventional techniques. Shale oil, also known as kerogen oil, is found within rock formations that bear large quantities of kerogen and similar deposits that produce oil when refined.[15] Shale oil is qualified to become the main source of unconventional oil throughout the world given the huge reserves that are available, especially in North America, which contains the largest and richest shale oil formations.

In this regard, "tight oil,"[16] is, in reality, not different from conventional oil in terms of quality since it is light and does not feature high levels of sulfur. However, the

[13] Gordon, "Understanding Unconventional Oil".
[14] Ibid.
[15] See http://www.spe.org/glossary/wiki/doku.php/terms:oil_shale.
[16] Tight oil refers to the light crude oil confined in shale, limestone, and sandstone formations and can be characterized as having very low porosity and permeability.

unconventional nature of the geological reservoirs that contain tight oil deposits necessitates the employment of complex and expensive techniques to extract it, leading to its classification as "unconventional oil". On the other hand, shale oil is an unconventional form of oil that is trapped in rocks with extremely low permeability. Thus, it is an oil that is still in its early stages of geological formation, requiring an expensive heating and refining process in order to be extracted.

It is expected that the production of kerogen oil will rise from now until 2035. In the US alone, which contains large resources of shale oil, especially in the Green River formation covering Colorado, Utah, and Wyoming, the amount of recoverable shale oil reserves exceed 800 billion barrels of oil, according to a 2011 report by the National Petroleum Council.[17] The mass production of shale oil remains a future potential, but there is no significant production from these resources so far. It is possible that the production of shale oil will increase in the coming years to reach one million barrels per day in 2035, which could subsequently be much higher if economically-viable techniques become available, and if the environmental damage can be minimized.[18] The available reserves of shale oil show this form of energy to be one of the most important sources of unconventional fossil fuels in the world. In addition to the abundance of shale oil in North America, it is also available in large quantities in Brazil, historical Palestine, Jordan, Indonesia, China, Australia, Estonia, France, Spain, Sweden, Great Britain, and South Africa.[19]

As indicated above, conventional oil and gas produced in limited geographic regions have dominated the energy system throughout the 20th century. These reserves still represent the majority of oil and gas produced globally today. However, the recent growth in the share of unconventional oil and gas in the global energy mix, especially in the US, points to an essential shift in the quality of future oil and gas, as well as a change in the production geography of these resources. The percentage of conventional oil production will decrease from 80 percent—compared to 20 percent unconventional oil—to 60 percent while the share of unconventional oil will rise to 40 percent of global oil production by 2040.[20]

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[17] National Petroleum Council, "Prudent Development," 46.
[18] Ibid., 50.
[19] Gordon, "Understanding Unconventional Oil," 12.
[20] Ibid., 4.

This ongoing shift is not limited to the use of new types of oil outside the Arab world; this change will also affect the political geography of oil since the majority of unconventional oil resources are concentrated outside the Middle East region, most notably in Eastern Europe and North America.[21] In its 2011 report on the future of energy in the world, the IEA predicted that North America's unconventional petroleum reserves could exceed the conventional oil resources in the Middle East by 50 percent.[22]

### The Current and Future Energy Situation

The energy market is in constant flux with some believing that the role oil plays will recede in the global energy mix, leaving a greater role for alternative energies. Moreover, there are indications that the current oil economy, which is characterized by very high oil prices in international markets, will not only encourage the development of new and alternative energies that have a relatively high production cost, but will also encourage the trend toward new forms of oil that have a higher production cost compared to conventional petroleum.[23] Expected investments will exceed a trillion dollars in the coming decade. If the oil market were to be left solely to the laws of supply and demand, unconventional oil would likely dominate the global energy system. Based on these premises, the long-term trends in the international energy system can be summarized in the following points:

- All studies indicate that there is no structural deficiency in the sources of energy and that the global oil supply, estimated at 93 million barrels of oil per day, is higher than global demand, which is estimated to be 88 million barrels per day.[24] Furthermore, there is a consistent increase in proven global oil reserves.[25]
- Fossil fuels (oil, gas, and coal) continue to dominate the international energy mix, reaching 87 percent of global energy consumption. Renewable energy represents no more than 2 percent of the global consumption of energy.[26]
- Oil remains the dominant fuel source, representing 33.1 percent of global energy consumption. However, there has been a decrease in the percentage of oil

[21] Map 1 in the Appendix.
[22] Ibid., 10.
[23] Ibid., 4.
[24] BP, *Statistical Review of World Energy,* 3.
[25] Ibid., 1.
[26] Ibid.

consumption for 12 successive years in favor of gas and coal, both of which have witnessed a brisk growth estimated at 5.4 percent annually in 2011.[27]

- Data covering energy consumption in the world indicates that focus of global consumption is shifting from the OECD member countries toward developing economies, especially in Asia, headed by China and India. According to a 2012 IEA report, 96 percent of the expected increase in global energy demand will come from outside the OECD region from 2010-2035.[28]
- The oil revolution witnessed in the US is not a temporary phenomenon; rather, it is the most important revolution the oil sector has seen in decades, and it can be replicated in other parts of the world. It is possible for this revolution to produce spectacular results in the long term.[29]
- Thought it may be true that the age of cheap oil is over, technology and the scaling of projects can lower costs, as the experience of oil and gas production from the North Sea has demonstrated.[30]

The main event that will herald a change in the global oil map is, indisputably, the oil revolution in the US. Additionally, the shale gas revolution has already begun, permitting the US to dispense with gas imports in less than five years.

## The Oil Revolution in the United States

As explained above, during the past decades the oil market has been characterized by the emergence of new areas for the exploration and/or production of unconventional oil, such as in Canada (oil sands and tar oil), Venezuela (extra-heavy oil), Brazil (oil produced from under extremely deep waters), and, above all, the US. The oil sector has benefited from the shale gas revolution by adopting new technologies.

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[27] Ibid., 5.
[28] IEA, *World Energy Outlook,* 56.
[29] Maugeri, *Oil: The Next Revolution,* 6.
[30] When oil was discovered under the North Sea in the 1970s, the extraction of the oil deposits was initially deemed to be an extremely arduous, complex, and expensive task as production took place in waters that were 100 to 200 meters deep, and over a kilometer under the seabed. Nevertheless, due to the rise in oil prices and the political will of Western countries, the production of North Sea oil became an economically-viable operation. After 10 years of exploration, production, and infrastructure construction, the cost of producing oil in the North Sea decreased by 50 percent. Today, major oil companies can economically produce oil in waters that are more than 3,000 meters deep, and from oil reservoirs that lie more than 6 kilometers under the seabed. North Sea oil production, which was previously seen as extremely complex and expensive, has now become a routine operation. Oil that is seen today as too difficult and too expensive to extract will likely become easy and cost-efficient in the future.

## The Shale Gas Revolution

Throughout the past five years, the significant increase in the production of shale gas in the US has led to a state of national self-sufficiency, with the possibility of exporting gas to international markets starting in 2020, and according to a 2012 IEA report on the future of global energy, Canada is in a similar situation.[31] The production of shale gas in the US went up from 0.1 trillion cubic feet in 2006 to 4.8 trillion cubic feet in 2010; shale gas production has risen from less than 2 percent to 23 percent of domestic gas production.[32] This revolution in gas production became possible because of a breakthrough in extraction technology, specifically the use of horizontal drilling and hydraulic fracturing. The process requires pumping a mixture of water, sand, and chemicals under high pressure to fracture the rock layers containing gas in order to free the gas that is confined within them.[33]

In 2000, these techniques were widely employed for the first time in the Barnett shale gas formation in Texas. Oil explorers have known about hydraulic fracturing technology since the 19th century, but it has taken years of development—since the 1950s—to reach fruition and increase oil and gas production in the US. A second phase in the evolution of this technology began in the mid-1970s, when the US Energy Information Administration sought, along with a number of private partners, to develop technologies that would allow the commercial production of gas from the geological basins in the East. This permitted the development of various technologies, including horizontal drilling, to extract shale gas. The Mitchell Energy and Development Corporation benefited from these technologies in the 1980s and the 1990s by turning the shale gas experiment into a significant economic reality. After their success in producing shale gas in commercial quantities, other companies rushed to replicate its success, spreading to geological formations across the US. After a decade of development and production, the US' production of shale gas has risen from zero in 2000 to more than 130 billion square meters of natural gas annually.[34] This has resulted in a sharp decrease in the price of natural gas on the American market; the price of gas reached historic lows and the US is now inching toward achieving self-sufficiency in gas production, with speculation that it may become a gas-exporting nation.

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[31] Ibid., 68.
[32] US Energy Information Administration, "Review of Emerging Resources".
[33] Figure 5 in the Appendix.
[34] Maugeri, *Oil: The Next Revolution,* 44.

## The Coming Shale Oil Revolution

The revolution that America is witnessing in the production of shale oil is a replication of the shale gas revolution. The same techniques have been used to produce shale oil, allowing for the recovery of massive quantities of oil. The US has, in fact, registered successive leaps in its shale oil production since 2008.[35] This success is primarily attributed to both new discoveries in extraction technology, and highly competitive environment and the openness of the American market compared to other economies around the world. Given the revolution experienced by the US in the production of unconventional oil and gas, it is clear that the existence of a competitive market and a level playing field have encouraged innovation that has led to the exploitation of unconventional resources that were difficult to reach in the past.

The expected decline in US oil imports, from 9.5 million barrels per day in 2011 to 3.4 million barrels per day in 2035, is mainly the result of the increased production of shale oil from now until 2020. After that time, the decline of imports will primarily be the result of qualitative evolution in the efficiency of vehicle engines, as well as the use of bio-fuels and natural gas in the transportation sector.[36] The drop of oil imports and the increase in gas exports will positively effect on the US trade deficit, especially if one takes into account that oil imports in 2011 alone constituted two-thirds of the deficit in the trade of goods. In addition, a positive economic stimulus will be provided to the US economy through the export of gas.[37]

## Potential Hurdles for the Oil Revolution

The US faces a number of hurdles in their energy shift that might increase the cost, or even delay this transformation, but they will not prevent it from taking place. The first relates to the regulatory framework that governs the transportation of oil within US states andterritories. The US energy market is subdivided into five distinct markets (based on the Petroleum Administration for Defense Districts):

- PAD District 1: the East Coast market
- PAD District 2 and District 4: the Central US market
- PAD District 3: the Gulf of Mexico market

[35] IEA, *World Energy Outlook,* 75.
[36] Ibid., 76.
[37] Ibid.

- PAD District 5: the West Coast market

It is ironic that the laws governing the US, the country that most staunchly defends the principles of free trade and free market access, do not allow the free transportation of crude oil within its border, and prohibit the export of oil to foreign markets.[38] The second major hurdle, related to the first, is the absence of the needed infrastructure to refine and transport oil between markets within the US. It is essential that there is a crude oil pipeline connecting the East and the West Coasts, and another connecting the Gulf of Mexico to the East and West Coasts. Furthermore, the East Coast is not connected to the North Central region, where a large portion of the American shale oil is currently being produced.[39] However, in March 2012, President Obama stressed his support for the expansion of the oil pipeline network in the US, alluding to how the current situation is expected to change radically during President Obama's second term.[40]

The negative environmental impact of the hydraulic fracturing technology is a major hurdle for the energy sector. The fracking technique used is reported to pollute groundwater reservoirs with the chemicals that are injected in the wells during the hydraulic fracturing process. The possibility of damage to the environment cannot be denied, though there is a good amount of exaggeration in assessing the scale of the harm caused to the environment and the groundwater. Documented incidents show that the major cause for environmental damage has been weak regulation and insufficient public supervision of the companies that employ hydraulic fracturing, and that the companies responsible for harming the environment have been small firms that did not take the necessary precautions to avoid such incidents in order to lower production costs. For these reasons, reinforcing regulation and tightening public supervision over the companies that work in the field are measures that can minimize the negative repercussions of the hydraulic fracturing technique. Furthermore, the strategic dimension of this newly discovered wealth will not permit the revolution in unconventional oil and gas to be delayed or halted. It is notable that the negative aspects of these technologies did not stop the development of shale gas.

[38] Maugeri, *Oil: The Next Revolution,* 55.
[39] Map 2 in the Appendix.
[40] Ibid., 56.

### Early Signs of a Revolution in Unconventional Resources in China

The ongoing revolution in the United States' energy sector is doubtlessly rearranging the global energy situation with long-term repercussions since the US imports 20 percent of its total energy needs. However, the continuing increase in the production of shale oil and gas, in addition to the increasing production of biofuels, will allow the country to achieve energy self-sufficiency by 2035.[41] The US will also become less reliant on imported oil from the Middle East region. Already, oil imports from the region have decreased from 2.8 million barrels per day in 2000 to 2 million barrels per day 2011. These imports are expected to lower further to 0.3 million barrels per day in 2005.[42] One should take note that the US is expected to become the largest oil producer in the world after Saudi Arabia by the year 2025.[43]

As the US undergoes this gradual shift toward self-reliance in energy production, Europe and Asia will become more dependent on oil imported from the Middle East, with China and India at the top of the list. China, for instance, appears to be preparing for this new strategic situation through the notable and increasing presence of its national oil companies in Africa and the Middle East, alongside Chinese efforts to forge stronger political and economic links with these countries.[44] At first glance, it would appear that the decrease in demand for imported oil in North America would be replaced by increased demand in Asia, which would then contribute to stabilizing the price of oil and avoiding a collapse in prices. However, this would only take place if one assumes that Asian countries, such as China and India, will not attempt extract their own shale oil and gas. In fact, these countries have demonstrated a serious and rising interest in the US' experience, and their governments have commissioned studies to assess their potential resources of unconventional oil and gas. Initial figures indicate that Chinese shale gas resources greatly exceed American reserves by as much as 50 percent and may exceed 1,375 trillion cubic feet of technically-recoverable gas.[45] This amount would be enough to fulfill Chinese gas demand for more than 200 years.[46] On the same front, Royal Dutch Shell signed a contract to explore and produce shale gas in China last November with

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[41] Ibid., 49.
[42] Ibid., 79.
[43] Ibid., 81.
[44] Ibid., 80.
[45] Gismatullin, "Shell to start," 2012.

[46] Evans-Pritchard, "China claims world's biggest shale".

the China National Petroleum Corporation.[47] Judging by the American experience, one cannot discount the possibility that shale gas production will lead to shale oil production, which would reduce the proportion of imported oil in Chinese oil consumption. For that reason, one cannot ascertain with confidence that the oil market will enjoy long-term stability and that oil prices will remain high; rather, pressure will increase on the price of oil, bringing a serious possibility of a price collapse. The same applies to natural gas prices in the medium and long term. This thesis is further supported by strong indications of the availability of shale oil and gas in various other regions around the world, such as Argentina and the Ukraine.[48] Thus, the long-term economic, political, and geopolitical repercussions of these expected shifts on the GCC states merit analysis.

## Oil in the Political Economy of GCC Countries

It is an undisputed fact that oil rents and proceeds have had a central effect on the economies of GCC countries since the 1930s when oil was discovered in the Arabian Peninsula. This wealth has become the main axis of the economy and politics in the Gulf, in a manner that has directly or indirectly affected all aspects of life in Gulf societies. On the local level, these oil-based economies have created governments that are linked to their societies through a socio-political contract that is characterized by the distribution of benefits to citizens through social services and high government spending in exchange for the citizens' abdication of their right to political participation. Regionally and globally, the Gulf lies at the heart of the world energy map due to the abundant reserves of oil and gas in the region. The influence of the oil wealth is not limited to the oil-exporting Arab countries, but extends to other Arab states that lack natural resources through the migrant remittances transferred from oil-producing countries. In 2011, the Egyptian government gained USD 8 billion from Egyptian labor in Saudi Arabia alone; in addition, Arab oil exporters provide direct monetary aid to the Arab countries that are bereft of oil wealth. In this regard, oil wealth has been, and remains, a significant factor in shaping the economic, political, and cultural identity of the Arab world. For this reason, economies of the Arab oil-producing countries, especially the Gulf countries, are more cyclical in nature than economies with comparable levels of development.[49] The over-reliance on oil wealth has negatively

[47] Gismatullin, "Shell to Start".
[48] Riley, "The Shale Revolution's".
[49] Koren and Tenreyo, *Volatility, Diversification and Development*.

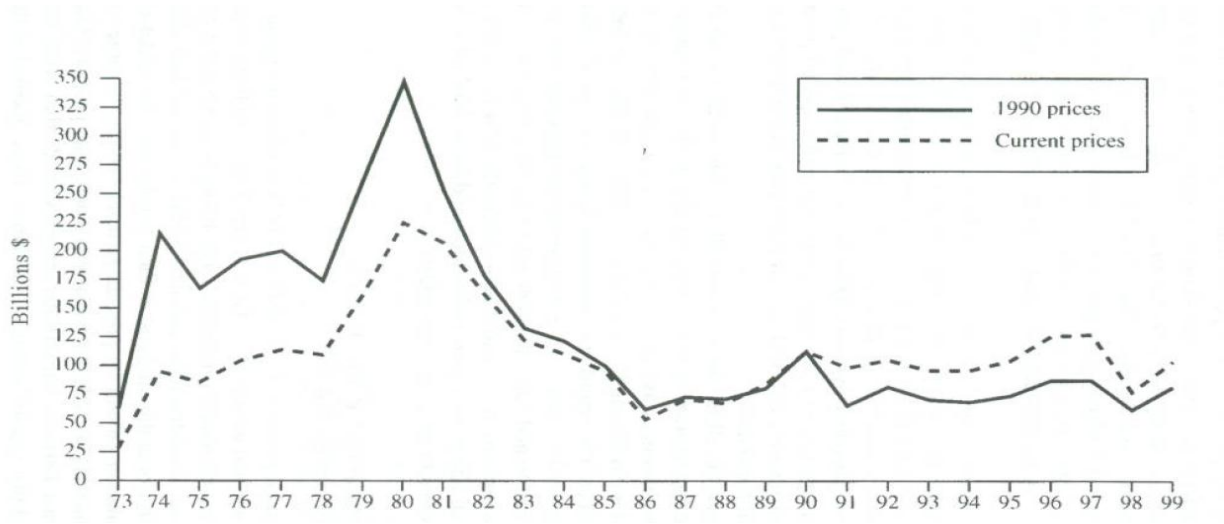
impacted the region's development, which suffers from structural deficiencies that hamper its advance toward comprehensive development—the result of an over-reliance on proceeds coming from outside the national economy, which are determined by the global oil market and its constant fluctuations. The possible repercussions of the increasing role of unconventional oil on the international markets, particularly that of the US, can be learned from the previous oil crises.

### Previous Oil Crises and their Repercussions

The rise in oil prices in the 1970s led to a number of new decisions and policies in the major industrial countries aimed at lowering oil consumption and reliance on OPEC oil producers. These countries encouraged the development of energy-saving technologies and the production of oil from new fields outside of the OPEC countries, such as North Sea oil, despite its high production cost. These decisions, enacted in tandem with the economic recession that hit the global economy during the 1980s, led to a drop in global oil demand and heralded a phase of continuous decline in oil prices that lasted until the late 1990s. The price per barrel went down by more than 40 percent in relative value between 1981 and 1996 and by more than 59 percent in real value. This negatively impacted the revenues of all oil-producing countries, especially those of the GCC.[50] For example, GDP per capita in Saudi Arabia went down from USD 18,039 per year in 1981 to USD 7,181 in 1998, a situation that was mainly a result of the significant fall in oil prices during the 1980s and the 1990s, coupled with fast-paced demographic growth in Gulf countries.[51]

[50] Rivlin, *Economic Policy and Performance*, 51.
[51] Niblock and Malik, *The Political Economy*, 117.

**Figure 1: Oil Proceeds of OPEC Countries between 1973 and 1999**




**Source:** Rivlin, *Economic Policy*, 50.

Demographically, the population in the Gulf is currently dominated by youth. In Saudi Arabia, for example, those aged 15 years or younger represent 40 percent of the total population, while those under 25 years of age represent more than 60 percent.[52] A population pyramid of Gulf countries exemplifies that satisfying the demand for new jobs will require additional financial resources and extensive investments in development projects. Furthermore, the quality of the jobs required is an important issue. Due to the immense changes witnessed by Gulf societies in recent years, and the young generation's desire to acquire jobs that fit their academic qualifications and culture, fulfilling these demands will place a large and increasing burden on the national budget of these countries. Given the future projections of oil income, these job demands will remain unfulfilled. Ultimately, there is an inevitable equation between the resources available and the demand for certain resources: the higher the revenues from oil exports, the higher the demand for social and economic services. Accordingly, Gerd Nonneman, Dean of Georgetown University's School of Foreign Service in Qatar and Professor of International Relations & Gulf Studies, notes that the future expansion in the production of oil and gas in the region does not appear sufficient to fully satisfy the

[52] Nonneman, "Governance, Human Rights and the Case," 8.

expected rise in social demands and demographic growth, which could then undermine the rentier social contract that has historically shaped the policies of this region.[53]

The spike in oil prices during the 1970s prompted Arab governments to expand their budgets and increase investments in development projects, leading to deficits in the balance of payments and forcing these governments to resort to foreign loans during the 1980s. After the collapse of oil prices in the mid-1980s, oil-producing Arab states suffered economically, and as a result, the economic aid that was sent from rich Arab countries to poor Arab countries was also curbed, forcing some Arab governments to resort to loans from the International Monetary Fund and to undergo its structural adjustment programs. The resulting economic, social, and political repercussions on Arab societies were substantial; the most dramatic of these repercussions was the civil war that flared in Algeria that lasted throughout the 1990s.

The economic crisis of the 1980s and 1990s was not solely caused by the collapse of oil prices, but also by the emergence of other factors. Demographic growth, social changes, shifts on the international scene (e.g., the collapse of the Soviet Union and the Eastern Bloc), and regional security crises—the First Gulf War in 1990-1991, which resulted in domestic and external pressures to enact political reform, and the Second Gulf War in 2003, which led to direct Western military intervention under the US' leadership—all played a role.[54] However, the drop in oil prices negatively affected the budgets of these governments, limiting their ability to perform their distributive role within the rentier system of the GCC countries.

Oil revenues have also indirectly affected these countries considering the massive investments the Gulf countries made in education, health, infrastructure, and industrialization over the last four decades. These improvements have radically changed these economies and societies, which have witnessed the highest rate of demographic growth throughout the world. These countries have also become more diversified and better integrated in the global economy, raising the bar for expected social services, such as employment, health, and education. This is key because spending on social

[53] Ibid., 6.
[54] In this context, the economic crises went in tandem with the tenure of Ronald Reagan in the United States and Margaret Thatcher in the United Kingdom, both of whom reoriented the Western—and, subsequently, the global—economy toward liberal economic policies. This was part of their promotion of the Washington Consensus, which called for the reduction of the role of the state in economic development. Furthermore, both Reagan and Thatcher contested the notion of providing monetary aid to the poor countries.

services engenders higher expectations in terms of future employment, especially because of the expanding demographics and the emergence of mass public education. Moreover, the GCC countries have adopted a public employment policy that has led to the creation of an important financial burden on the budgets of these states. Even the regional crises witnessed in the Gulf and the political and military foreign interventions were directly related to the stature of the Gulf states and their role in the international map for oil and gas.

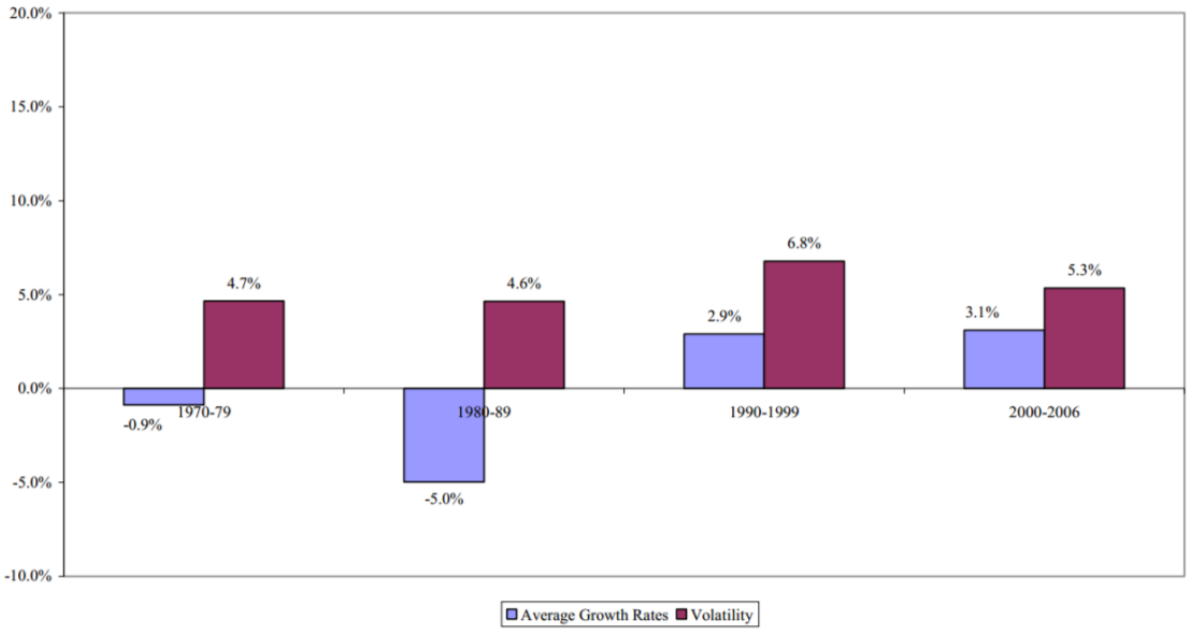
During the 1990s, the GCC states suffered economically as a result of their government's financial situation after the collapse of the price of oil in international markets, which began in 1986 when the price of oil went below USD 10 per barrel.[55] Saudi Arabia was among the countries most affected by this slide in prices, as it was also influenced by external pressures after the First Gulf War and Western military intervention in the region. All of these factors prompted King Fahd to announce political reforms in 1992, including the issuance of the Basic Law of Saudi Arabia, according to which an appointed Shura Council was founded a year later for the first time since the establishment of the Kingdom in 1932.

The economic performance of the GGC states is characterized by its volatility; in Figure 2, the average annual growth of GDP per capita and the level of volatility measured on the basis of the standard deviation of the annual growth rate is presented. In this way, one can observe fluctuations, representing instances of "oil shocks," in average growth each decade. The objective behind presenting this data is to demonstrate the instability of the GCC economies and their economic vulnerability. Most GCC states, with the exception of Kuwait and Qatar, witnessed significant economic growth during the 1970s, with rates of 12.6 percent in the UAE, 5.7 percent in Saudi Arabia, 5.5 percent in Oman, and 2.9 percent in Bahrain. In the 1980s, all Gulf countries except Oman saw their economies shrink, with rates exceeding -3.6 percent in Kuwait and -6.4 percent in Saudi Arabia.[56] With the rebound in oil prices during the late-1990s and the early-2000s, economic growth rates are back on the rise in all GCC states, and they maintain an exceptional economic stability. In sum, the common denominator between all Gulf economies is their extreme instability and the tie between their economies and the oil market's volatility.

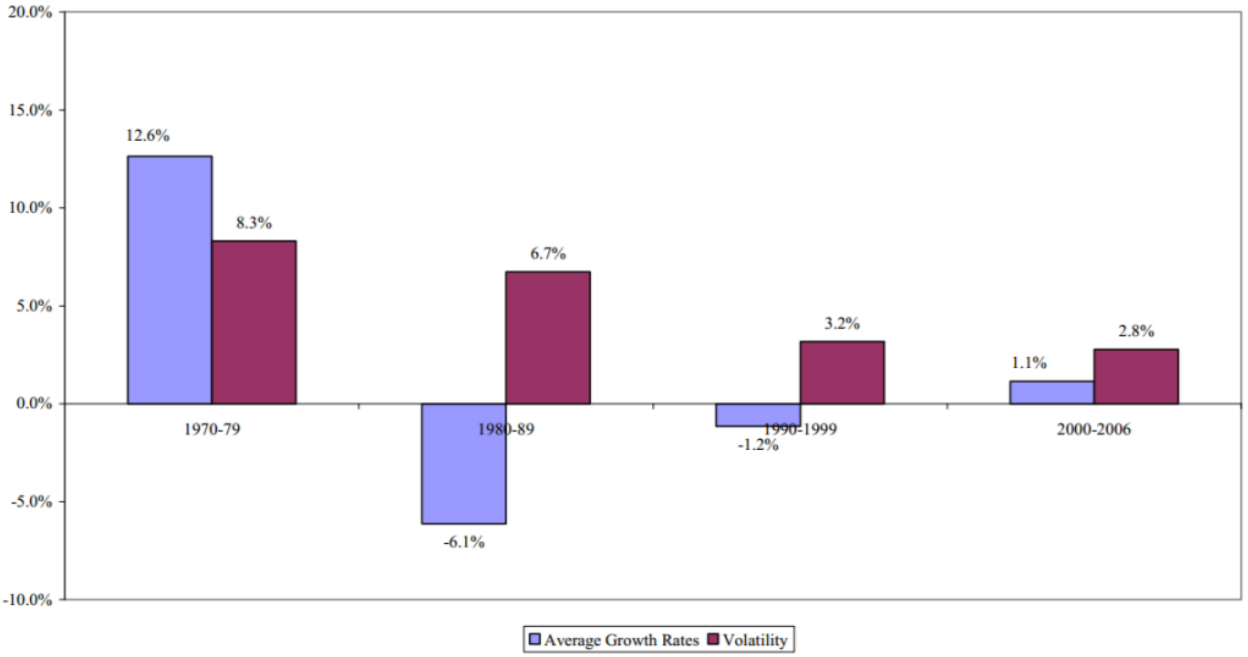
[55] Nonneman, "Governance, Human Rights and the Case," 9.
[56] Miklos and Tenreyo, *Volatility, Diversification and Development*, 189.

**Figure 2: Average Yearly Growth Rates and Volatility in the GCC states, 1970-2006**

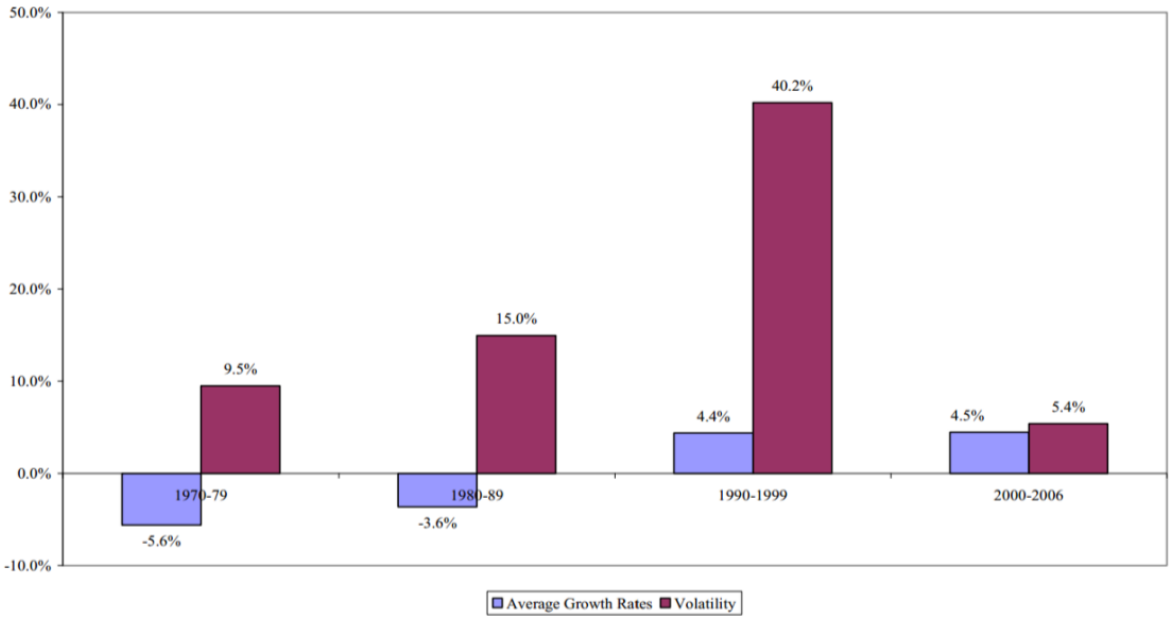
Qatar



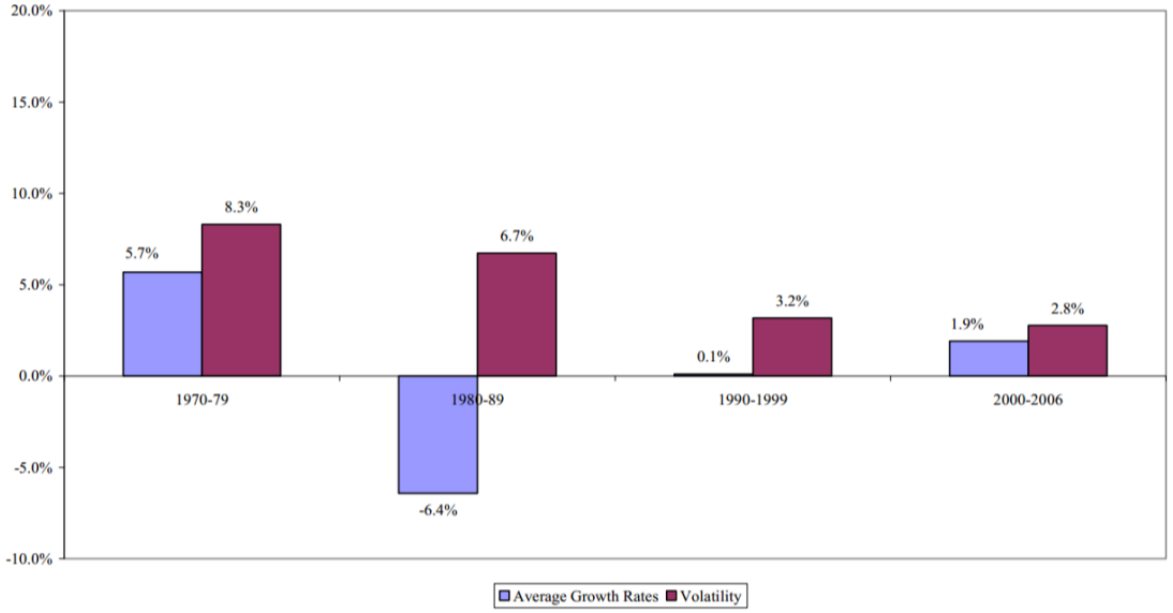

The United Arab Emirates



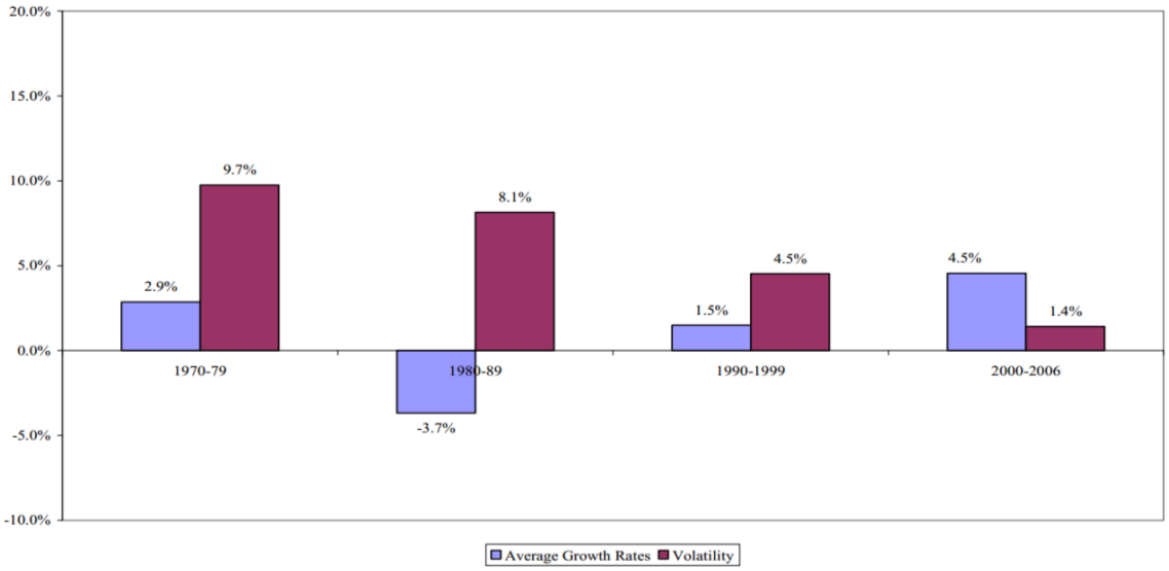
Kuwait



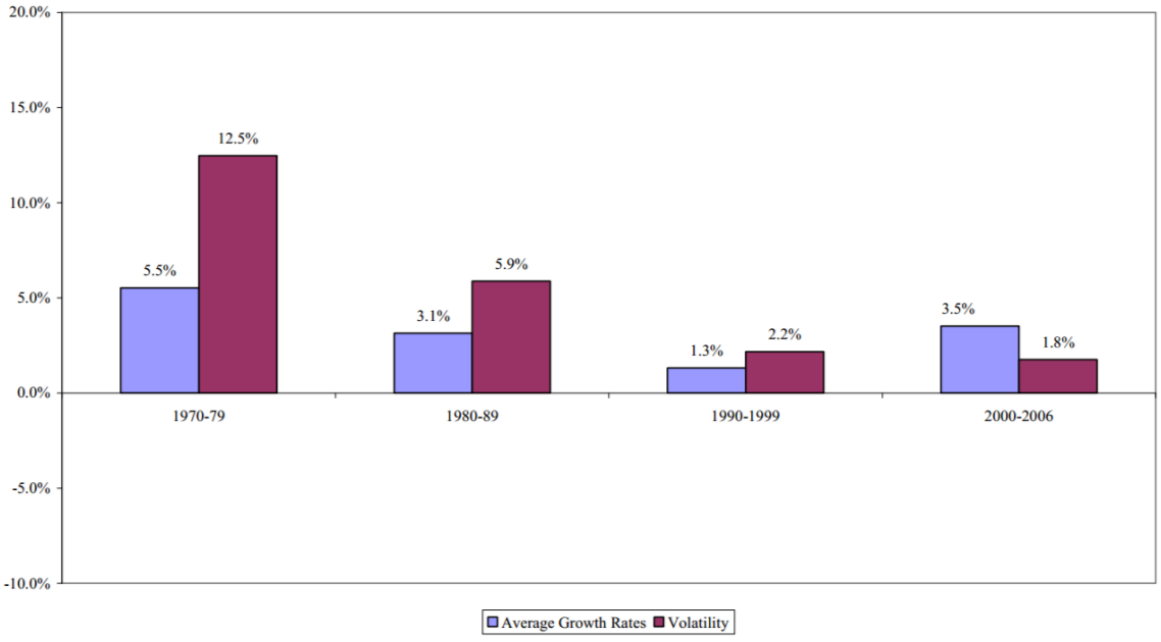

Saudi Arabia



Bahrain




Oman

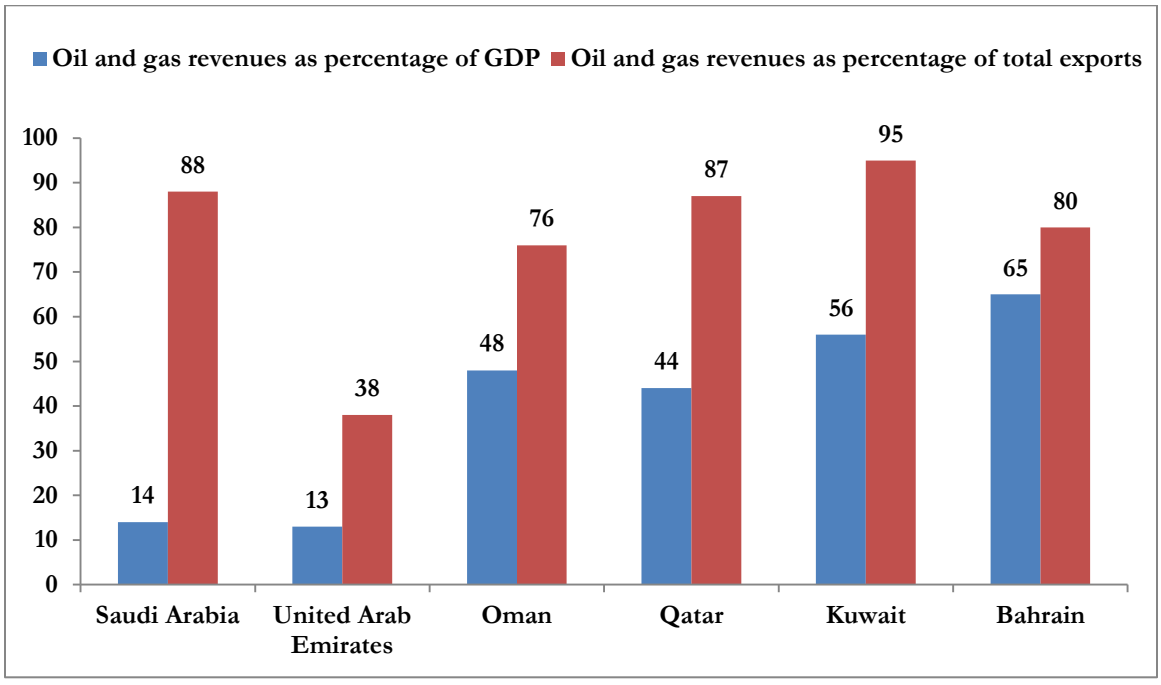



**Source:** Koren and Tenreyo, *Volatility, Diversification and Development*, 190-191.

The GCC states have made massive investments outside the energy sector to diversify their economies, and have relatively succeeded in lowering the proportion oil proceeds

represent of their gross domestic products (GDP). "Most notably, the United Arab Emirates have seen a steady decline in mining as a share of GDP, from above 70 per cent in the 1970s to around 30 per cent in the 2000s, despite the sharp increase in oil prices in recent years."[57] Nevertheless, despite these achievements, the GCC economies continue to be characterized by price fluctuations as oil revenues still play an important role in their state budgets; additionally, these governments have increasingly high expenditures in order to offer extensive social services to their citizens in accordance with the rentier state model, develop their infrastructure, keep up with economic growth in the Gulf, and fund their infrastructural and industrial projects. In addition, demographic growth is increasing due to natural birth rates among the local population and the influx of foreign labor. To a large extent, GCC states still rely on oil and gas income, which represents on average more than 40 percent of the GDP and around 70 percent of the hard currency earnings of these states.

**Figure 3: Percentage of Oil and Gas Revenues for GCC countries in 2008 (%)**[58]

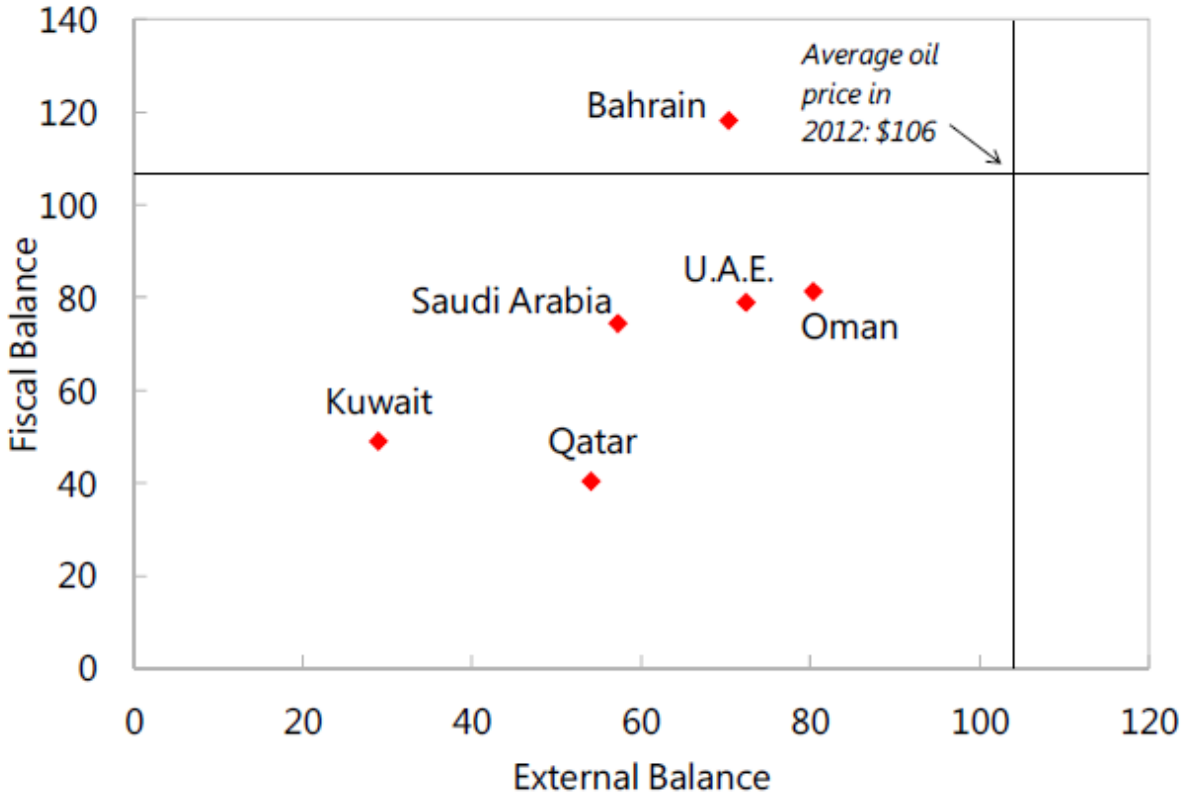



[57] Koren and Tenreyo, *Volatility, Diversification and Development*, 192.

[58] See: Central Bank of Bahrain, Economic Indicators, December 2008; Central Bank of Kuwait, Quarterly Bulletin, July-September 2008; Central Bank of Oman, Annual Report 2007; Qatar Central Bank, Annual Report, 2007; Saudi Arabian Monetary Agency, Annual Report, 2008; Central Bank of the United Arab Emirates, Statistical Bulletin, July-September 2008 and Economic Bulletin, various issues.

The budgets of the GCC states are currently characterized by a monetary and external surplus due to the elevated oil prices on the world markets. In 2011, financial surpluses reached around 13 percent of the GDP, with the external surplus exceeding 24 percent of the GDP.[59] The financial situation of these countries is expected to remain the same in the short run; however, the increasing expenditures that have resulted from the rise in the price of oil have caused the breakeven point for the GCC state budgets to rise to historical levels. This fact in itself engenders a structural weakness and a propensity toward fluctuation.

**Figure 4: Break-even Oil Prices for the GCC states, 2012 (US Dollars per barrel)**




Sources: Country authorities; and IMF staff estimates.

[59] International Monetary Fund, "Economic Prospects and Policy Challenges," 10.

Bahrain is the GCC state most vulnerable to oil fluctuation, where the breakeven point exceeds 110 dollars per barrel. It is followed by Oman (more than 80 dollars per barrel), the UAE (80 dollars per barrel), and Saudi Arabia (79 dollars per barrel). Qatar and Kuwait reach a breakeven point below 60 dollars per barrel. It is clear, then, that a significant collapse in the price of oil (below 80 dollars per barrel) would negatively affect most of the GCC economies. Nevertheless, one must not rely on this point as the sole measure, but should also take into consideration the scale of global demand for oil and gas since it is closely linked to the extent of development in oil and gas production in the major consuming nations, such as the US, China, and India. There is a real possibility that these states will develop their capacities to produce unconventional oil and gas in large quantities, which would doubtlessly affect the level of global demand for oil and gas produced in the GCC states.[60]

In fact, the high expenditures in Gulf economies due to the high oil prices may, in and of themselves, sow the seeds of future economic crises, especially if the price of oil collapses in the global market under the pressure of an increasing supply of unconventional oil. The entry of new players into the oil export market, such as with the US, which is expected to shift from an oil-importing country into a nearly self-sufficient country by 2035, will also play into the possibility for any future crises.

A number of experts and decision makers in the energy domain in Arab oil-producing countries claim that the cost of producing unconventional oil is too high, and that consuming nations and major oil companies are not prepared to either bear the immense cost or to turn their backs on the cheap oil produced in the Gulf. However, the experience of the 1980s and the 1990s demonstrates this is precisely what took place in Western countries—oil production in the high-cost regions expanded at the expense of production in low-cost regions, such as the GCC countries, where production fell or stagnated.[61]

If analysis is based purely on economic principles, economic rationality should prompt oil-consuming nations to encourage oil production where the cost of extraction is low, such as the GCC countries. Historically, however, the opposite has taken place. The 1973 oil crisis was spurred by the oil embargo imposed by the Arab oil-exporting

[60] Ibid., 10.
[61] Rivlin, *Economic Policy and Performance,* 52.

countries on the US, Western Europe, and Japan, which came about as a retaliation for these countries' support for Israel during the 1973 October War. This crisis constituted a major shock to the world economy, especially the economies of Western countries. During that time, the price of oil on the international market rose by 70 percent, which gravely affected the global economy, including a protracted worldwide economic recession.[62] The sharp increase in the price of oil affected the cost of importing oil and oil derivatives for the majority of countries around the world, especially Western countries as they tend to consume the most and are reliant on hydrocarbon imports. Between 1973 and 1987, this led to the adoption of consumption-curbing policies on the one hand—by increasing their energy system's efficiency and changing the consumption habits of society—and to the enactment of strategies by a number of countries to lower their reliance on imported oil by turning toward other non-OPEC oil-producing regions, especially outside the Middle East, such as the North Sea and Alaska, even though there was an increased production cost. Moreover, these changes have also led to the encouragement of the development and adoption of alternative or renewable energy sources.

Norway and Great Britain encouraged the exploration and production of oil in the North Sea through tax incentives and new policies. Simultaneously, a technological breakthrough lowered the cost of oil extraction from the North Sea fields, leading to a rise in production from 3.5 million barrels per day in 1988 to 5.9 million barrels of oil per day in 1996.[63] Based on this, Western governments are presumably willing to sacrifice the economics in exchange for strategic objectives relating to energy security. These countries are endowed with superior scientific and technological capacities that may permit them to decrease the high cost of production in the early stages as the production cost is usually seen to drop with the expansion and the scaling up of projects. For this reason, decision makers and experts in oil producing Arab countries, especially Gulf countries, rely excessively on an abundance of cheap oil though it carries a variety of risks; however, history has shown the flaws in this way of thinking.

[62] It would be difficult to determine the real reasons that led to the recession after the oil embargo crisis in 1973 since the crisis took place alongside the adoption of a number of new financial and monetary policies in Western countries that complicated the economic situation.
[63] Ibid.

## The Potential Scenario of a Price Collapse

The current oil market is characterized, as explained above, by a surplus production of 4 million barrels per day, which is enough to replace the production of any single large oil producer, such as Iran.[64] Furthermore, global oil production capacity exceeds global demand, a situation that will remain the same for at least the next decade due to the latest investments in production capacities. Many experts and decision makers in the field of energy believe that oil prices will remain high for a long time to come. Thus, they exclude the possibility of a price collapse in the medium and long term; nevertheless, there is evidence indicating the real possibility for a collapse in the price of oil in the long term. It would be difficult to predict the exact moment at which the oil prices could begin to slide in international markets, especially given that the majority of the projects that have recently been launched in the production of conventional and unconventional oil are still in their early phases, when costs peak—including infrastructure construction, production capacity development, transportation, and storage, as well as learning the use of new technologies. Historically, the oil market has had a fluid nature, with each "oil boom" usually being followed by an "oil bust".

Currently, many of the same characteristics as the time period directly preceding the price collapse of the 1970s are prevalent, primarily:

- There has been a technological breakthrough in the field of unconventional oil production with the shale gas revolution in the US, a situation similar to the exploitation of the North Sea oil and gas deposits.
- New discoveries of unconventional oil reserves have been located largely outside of the OPEC countries
- Governments have the political will to implement policies encouraging the production of unconventional oil in the US and Canada.
- The high prices of oil permit the profitable production of unconventional oil. The cost of producing a barrel of shale oil is usually between USD 50-65, while the price of oil is currently over USD 100 per barrel.[65]
- The price collapse in 1986 was preceded by a phase of intense investment in production capacity, benefiting from the rise in oil prices during the 1970s. This investment trend has also been seen since the beginning of the rise of the price

[64] Maugeri, *Oil: The Next Revolution*, 64.
[65] Ibid., 54.

of oil in 2000. This dynamic will lead to the expansion of production capacities and the saturation of the global oil market.

If the repercussions of the US shale gas revolution were projected onto the decreased prices for gas in the North American market, it would be logical to conclude that the shale gas scenario is on the cusp of repeating itself in the production of shale oil. Furthermore, there is a real possibility that this experience will also be replicated in other world regions, such as China. It appears that the long-term price collapse scenario is likely to take place between 2030 and 2035 if no other global economic crises take place before this date or technological breakthroughs occur in the domain of extraction or in other domains directly related to energy or oil.

### The Potential Repercussions of the Unconventional Resources Revolution on the GCC

Due to its status as a superpower, the US was and remains one of the countries most focused on the question of energy and access to energy sources. It enjoyed self-sufficiency in the production of oil until the mid 1940s, but by the mid-1970s, the US was consuming a quarter of globally marketed oil before beginning to reduce its reliance on imported oil in recent years.[66] This new position has important strategic repercussions that can be summed up as follows:

- One of the most important geopolitical transformations is the fact that Asia is becoming the main importer of GCC oil due to the US' projected achievement of near self-sufficiency in oil production by 2035.[67] This would make China and India the main importers of Gulf oil and major political players in the region.
- Reaching self-sufficiency in oil production does not necessarily mean that the US will isolate itself from the global oil market, nor does it mean that the Gulf region will be less important for American foreign policy.[68] The US' interest in the Gulf region began directly after the Second World War when the US signed long-term energy agreements with a number of countries in the region, despite the fact that America enjoyed self-sufficiency at home. The objective behind these initiatives was to prevent the Soviet Union from infiltrating the region and influencing the world energy market. Today, if the US decided to withdraw from the region they would lose their influence, thereby permitting China to influence

[66] IEA, *World Energy Outlook*, 75.
[67] Ibid., 49.
[68] Cordesman, "The Myth or Reality," 13.

the oil market and its prices. It is for that reason that it will not withdraw from the Gulf.

- Moreover, the growing dependence of China and India on Gulf oil could open the door to the possibility of an American-Chinese-Indian partnership in the management of security in the Gulf. India's interests in the region are more tangible than those of China, given the large size of the Indian labor force in the Gulf—over 6 million guest workers. According to a recent paper by the Center for Strategic and International Studies, the US has the means to reach near self-sufficiency in oil in the long term, which will require it to revise its posture on security in the Gulf and to assess the viability of establishing a multilateral security structure that includes the US, China, India, Japan, and other Asian nations. This would allow the US to lower its security and force-projection needs, especially when the desire of other powers to secure their own energy supplies in the future is taken into consideration.[69]
- With the increasing role of unconventional oil in the global energy mix, the oil industry will become more centered around countries such as Canada, the US, Venezuela, and Brazil due to their extensive reserves of unconventional oil.[70] The only Gulf state that will see its production rising is Iraq, which enjoys the fifth largest oil reserves in the world, and is currently the third-largest OPEC producer with production exceeding 3 million barrels per day. Iraq is currently on the verge of important developments in the field of oil production that will come into effect in the coming years.[71]
- On the domestic level, a collapse in the price of oil would doubtlessly have a negative impact on the GCC government budgets, especially if this takes place simultaneously with a shrinking global demand for Gulf oil, given the predictions that other oil-consuming countries such as China will develop their unconventional oil and gas resources.
- The financial difficulties that could befall the Gulf states would necessarily impact their ability to satisfy social demands and maintain the state's distributive role, which could engender acute political crises.
- The dearth of financial resources could then push Gulf governments toward external debt, requiring them to submit to the conditions of the lending

[69] Ibid., 15.
[70] Gordon, "Understanding Unconventional Oil," 10.
[71] IEA, *World Energy Outlook,* 387.

institutions if the oil bust were to last for more than five years. In fact، because of their massive foreign currency reserves, Gulf economies are capable of surviving an oil price collapse for a short period.

In short, if a real collapse in the price of oil takes place, the region will witness the same crises it experienced during the 1980s and the 1990s, but with a greater intensity than the previous oil busts as a result of the increasing need for social services given their high demographic growth rates.

## Conclusion

The potential fluctuations of the energy market and the prospect of oil depletion should not deter people; in the words of the former Saudi Oil Minister Ahmad Zaki al-Yamani, "humanity did not transit from the Stone Age to the Bronze Age due to a shortage of stones"; rather, it did so due to the discovery of bronze. It is true that the age of oil may end before oil resources are depleted; for this reason, historical experiences should guide decision-makers and experts into the future of energy. Furthermore, an overreliance on natural resources as a basis for providing for society, rather than building an economy on human resources and innovation in all fields—especially science and technology—is a structural problem in GCC economies. Unfortunately, these states, which have enjoyed most of the world's oil wealth since the 1930s, lack control over the technologies for the production of energy, despite the availability of all financial and human resources. For that reason, preparations for the transformation of the oil map are not limited to the adoption of temporary technical or financial solutions, but are part of a process that must be centered on a comprehensive development policy based on the human resources of society, and on fostering individuals who are capable of creating wealth through intellectual and scientific innovation.

Lastly, these recommendations are meant as a way of preparing for these future challenges:

- Political reform that increases political participation and good governance must take place because wider participation in decision making can create a sense of partnership, leading to active and positive participation in executing these decisions.
- A model of comprehensive development should be adopted, aiming toward the formation of a productive and innovative citizenry, in order to increase the

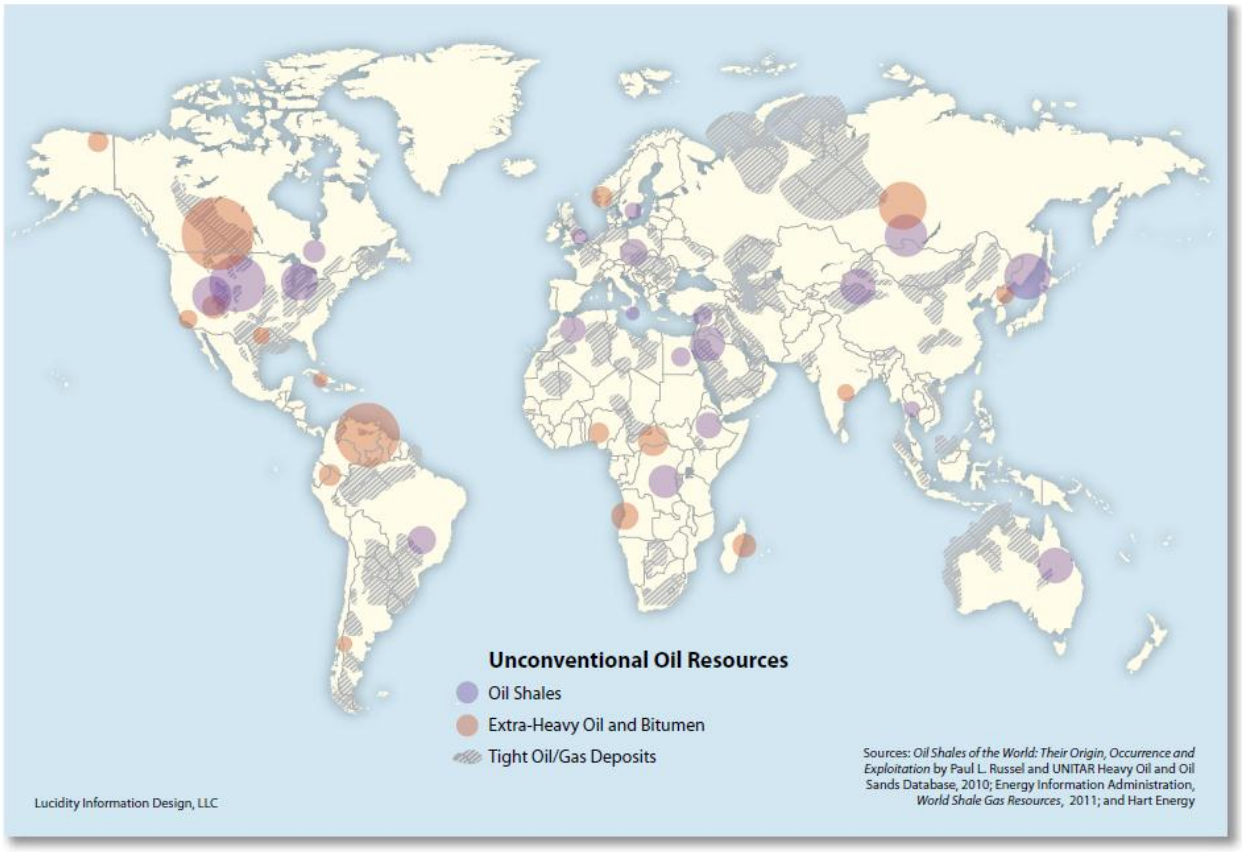
scientific and research capacities of Gulf states and cut down reliance on an expatriate workforce to develop the needed technologies in all fields.

- Efforts toward economic diversification, which began more than two decades ago in the GCC states, should continue so as to lower the GCC's economic dependence on the revenues of oil rent, particularly focusing on high added-value sectors, such as manufacturing.
- Gulf states and the Arab states must cooperate and coordinate with each other, with a specific focus toward economic complementarity as part of a unified Arab strategic vision that aims at developing collective Arab capacities in the face of current and future challenges in all fields, including security.
- Long-term planning is necessary in the field of research, emphasizing the importance of scholarly studies and projections as a necessary tool in policy-making, government planning, and corporate strategy, particularly in the national energy companies. For example, scenario studies are indispensable in the field of strategic planning and help minimize risks and fluctuations.
- National oil companies throughout the Arab world should invest in smaller companies in the US that possess the technologies needed to produce unconventional oil and gas in order to develop their capacities in the field of the exploitation of unconventional resources.
- The Majors"—corporations who bought such smaller companies in order to assimilate their talents and technical knowledge—adopted this strategy. These investments would not only permit an Arab presence in the unconventional energy markets, locally and globally, but also produce financial benefits.

The Arab world is in need of a qualitative leap forward—politically, economically, and socially—in order to prepare for the coming challenges in the coming years and to avoid the negative repercussions of an overreliance on oil wealth. This would permit the Gulf and the wider Arab world to not just surpass these crises with the least possible loss, but also benefit from them. There are signs indicating that the Arab Spring is beginning to prepare countries for this long-awaited change. Such transformations could lift the Arab world from its rentier culture, which naturally creates a state of vulnerability, and move it toward a culture of production and innovation that would play an active role internationally.

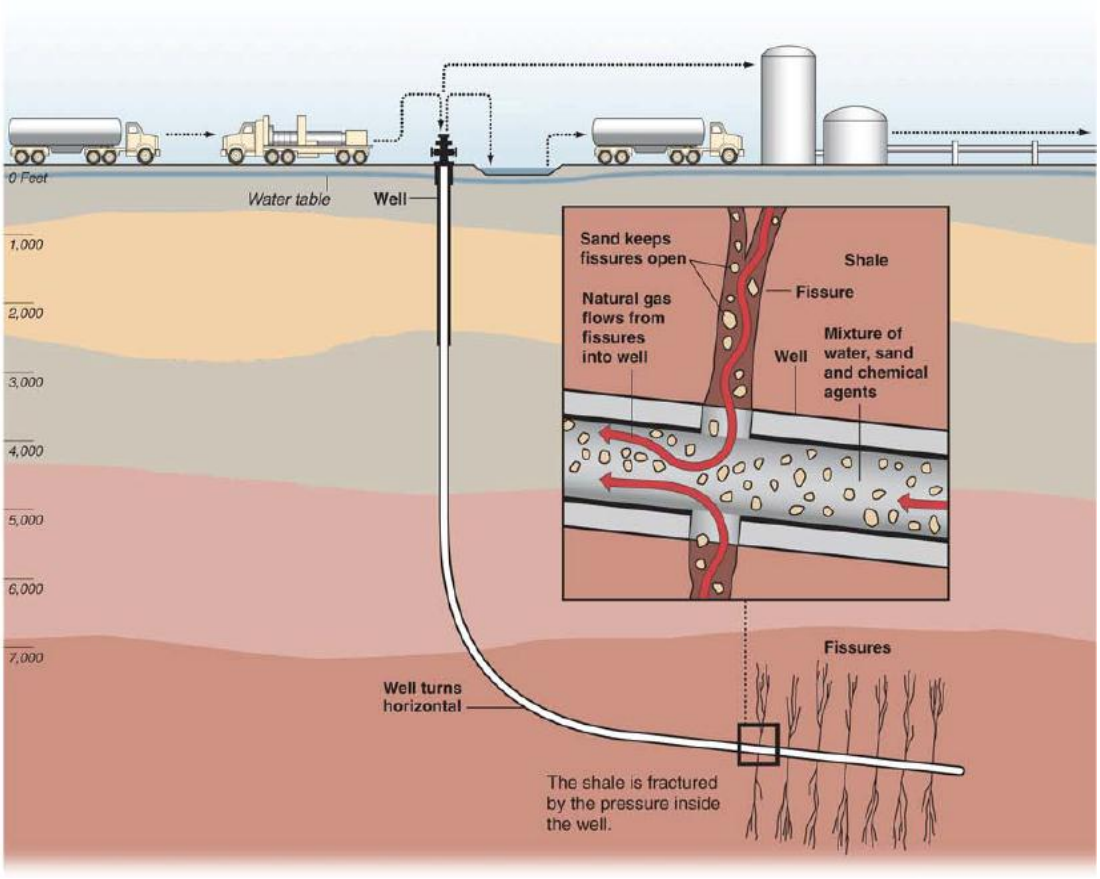
# Appendix: Maps and Graphs

## Map 1: New Geographies of Unconventional Oils



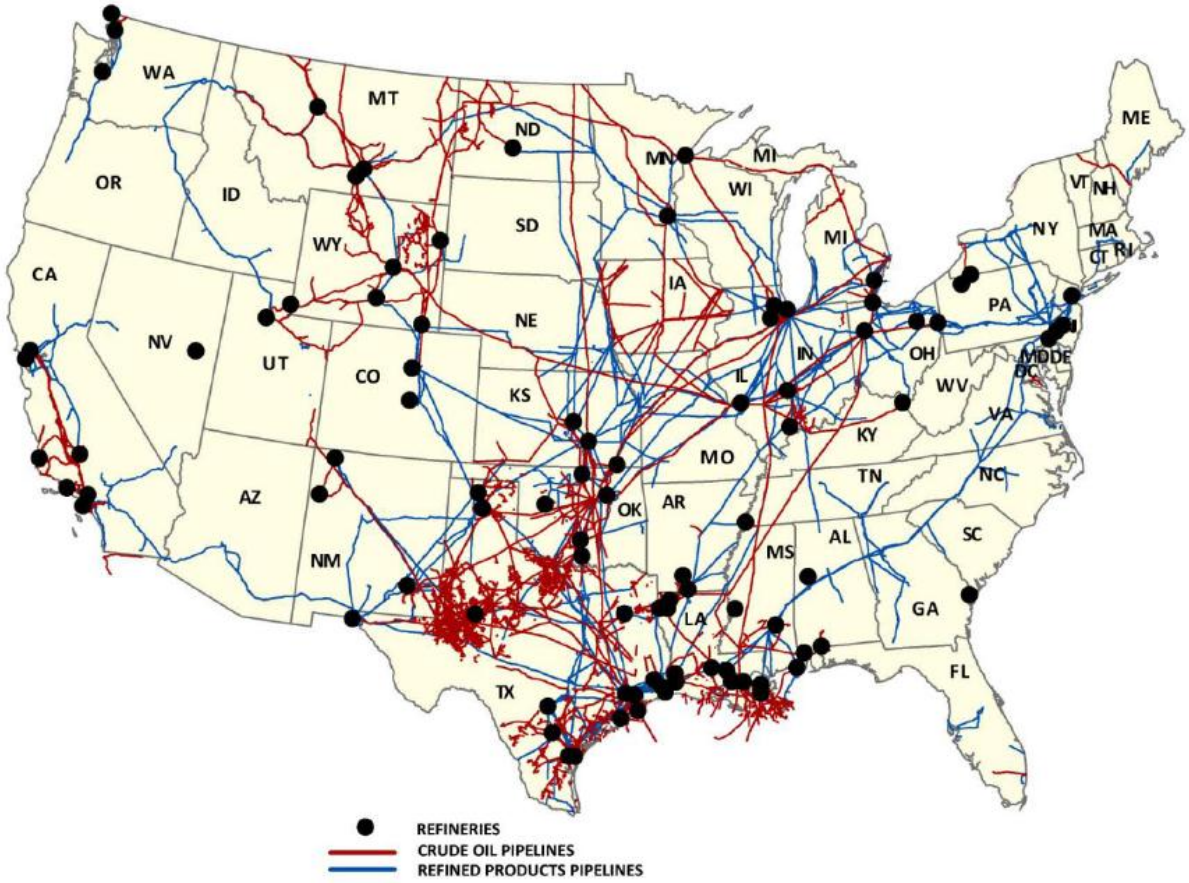

**Source:** Gordon, "Understanding Unconventional Oil".

**Figure 5: Illustration of Horizontal Drilling and Hydraulic Fracturing Techniques**




**Source:** Maugeri, *Oil: The Next Revolution*, 43.

**Map 2: Oil refineries and the US' Pipeline Network**




**Source:** Maugeri, *Oil: The Next Revolution*, 56.

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