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The Shale Revolution and OPEC: Potential Economic Implications of Shale Oil for OPEC and Member Countries

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Table of Contents:

I. Introduction

Throughout the 20th and 21st centuries, the petroleum industry has played a pivotal role in influencing the geopolitical, economic and human development strategies of both core and peripheral nations. Until recently, the debate over "peak oil" and "life after oil" had dominated energy industry discourse. However, due in large part to technological advancements—most notably, hydraulic fracturing—unconventional shale oil formations previously dismissed as economically infeasible have become a hotbed for new exploration. This development, when combined with exponential growth in developing Asian economies, stagnating economies in Europe, and the desire for oil-independence in the United States, has brought forth a paradigm shift for the oil industry and the geopolitics of oil. The central issue of this paper will focus on the potential of an international shale revolution, its impacts on OPEC market shares and OPEC responses to substantial shale developments. While the ultimate conclusion of this paper is partly inconclusive with regard to the development of shale plays outside of the United States, the prospective impacts of shale oil that this paper analyzes are far-reaching and carry significance concerning the future structure of oil markets, the effectiveness and viability of OPEC in the intermediate and long terms, and the dependency on OPEC oil for various segmented markets.

II. Methodology and Research Design

From the central question of this study—how would an international shale revolution affect OPEC market shares, and what response would OPEC have to the prospect of considerable shale oil production?—the following hypothesis emerges: a large-scale international shale revolution will have major consequences for OPEC market shares, and OPEC attempts to hinder shale development will prove ineffective, leaving power of the OPEC "oil weapon" marginalized. The hypothesis contains three variables to be measured: a) the potential of shale oil production from both a volumetric and geographic perspective, b) the implication of increased shale oil production for OPEC market shares, and c) the OPEC response to international shale development. These variables are elaborated and operationalized below.

a) The potential of shale oil in the US will be determined by outlining past and future of growth of shale reserves using available statistics and forecasts from the US Energy Information Administration. To date, there has been an insignificant degree of shale development outside of the US, so the same statistics for the US are not available for other countries. To determine shale potential globally, the analysis will rely primarily on the geographic location and size of known shale reserves. Additionally, to demonstrate the current and potential effects of shale oil, three countries in considerably different circumstances concerning oil will be analyzed. Those countries to be analyzed are the United States, China, and India. The United States has already begun to produce shale oil on a large scale and is forecasted to continue to do so. China and India, on the other hand, both have rapidly increasing appetites for oil, but they are fundamentally different in their capacity to capitalize on shale oil and increase domestic production.

b) To determine the potential impact of shale oil on OPEC market shares, the past level and direction of OPEC exports were first obtained using data from the 2013 OPEC Statistical Bulletin and US Energy Information Administration. To determine future demand for OPEC oil at the global level, forecast data from the EIA was used and a simple model built with the core assumption that demand for OPEC oil can be generally defined as the difference in global oil consumption and non-OPEC supply. At the regional level, forecasts for increasing or decreasing demand for OPEC oil specifically could not be attained. Instead, another simple model was built defining extra-regional demand for oil as regional oil consumption minus regional oil production. To create a forecast of US oil demand, a time series regression was employed, using historical EIA data of both total US crude oil imports and crude oil imports from OPEC countries. There was insufficient data to run the same type of regression with China and India. Alternatively, a simple model was used to determine their forecasted demand for oil imports, historical dependency on OPEC oil, past development of existing reserves, and potential for future development of shale and other reserves. Combining all of the modeled predictions for future imported oil demand with forecasts for consumption, a projection of future OPEC market shares was created.

c) The OPEC responses to the potential of substantial shale developments were analyzed using a game theory approach, focusing on the incentives that each evaluated situation presented. Furthermore, these responses were analyzed within the context of two frameworks: a perfectly collusive OPEC and an imperfectly collusive OPEC. The three hypothetical responses considered in those two frameworks are: 1. Maintaining business as usual, 2. Flooding the market to reduce the incentive for shale development, and 3. Cutting supply to operate as a fully profit-maximizing cartel.

III. Contextual Framework

To fully appreciate the current and prospective effects of shale oil on global oil markets and, more specifically, OPEC, it is necessary to specify a contextual framework through which a basis of comparison is provided.

a. Current Trends in Crude Oil Demand

Over the past decade, there have been significant shifts in where crude oil is being demanded. Developing Asian economies in countries like China and India have been the main drivers of increases in oil consumption. China, for instance, saw its economy grow an average of 10.4% per year from 1990-2010. Over the same time period, it experienced an average growth in oil consumption of 15.3% per year. The growth in Chinese oil consumption alone accounted for 33.7% of increases in total world oil consumption over those 20 years. From 2005 – 2013, the Non-OECD Asia region increased its share of total world oil consumption from 18.3% to 23.5%. These developing economies spurred Non-OECD Asia to overtake OECD Europe as the second largest regional consumer of oil in 2006.[1] Of course, this phenomenon could partially be attributed to the faltering economies of OECD Europe. Since 2005, crude oil consumption in OECD Europe has fallen over 2.4 million barrels per day, primarily driven by sluggish economic conditions.

Recently, the staggering economic growth in many Asian economies has slowed to more modest levels, but the intermediate and long-term forecasts for oil demand in these countries are still very strong. The EIA projects Chinese and Indian oil consumption to rise 22% and 16%,

[1] See Appendix, Figure 4

respectively, from 2013 – 2018.[2] Furthermore, by 2018, Non-OECD Asia oil consumption is projected to account for 25.9% of total world oil consumption, up from 23.5% in 2013.[3] Oil demand in other regions of the world is expected to remain relatively static through 2018. In sum, there have been significant changes in the geography of oil demand and those trends are forecasted to continue.

b. Recent History of OPEC

The Organization of Petroleum Exporting Countries (OPEC), established in 1960, provides member countries with arguably unprecedented control over petroleum markets. Since its inception, OPEC's share of global oil production has consistently constituted a major portion of total world production.[4]

i. Export Patterns

By region, the top three importers of OPEC oil are Europe, Asia, and North America, all of which have experienced, to varying degrees, changing circumstances involving OPEC oil exports. From the early 1990s through 2004, Asia was the largest regional consumer of OPEC oil exports, accounting for nearly 40% of total OPEC exports.[5] In the years following 2004, however, Asian economies have demanded significantly more oil exports from OPEC, leading to a 4.85 mbopd rise in OPEC exports to Asia from 2004 – 2012, an increase of 51%.[6] For the sake of comparison, during this same time period, total OPEC oil exports only rose 2.38 mbopd. The net effect of this is seen in Asia's share of OPEC oil exports, which grew from 42% in 2004 to 57% in 2012.

[2] Organization of the Petroleum Exporting Countries (2013)
[3] US Energy Information Administration. *Annual Energy Outlook 2013 With Projection to 2040*. (2013)
[4] Hansen (2008)
[5] See Appendix, Figure 6
[6] See Appendix, Figure 6

The reciprocated effect of increases in Asia's share of OPEC exports has been the long decline of Europe's demand for OPEC oil and the somewhat recent decline in North America's. From its peak in 1998, OPEC oil exports to Europe have fallen 2 mbopd, and, beginning in 2007, oil exports to North America have fallen 2.1 mbopd. These declines, along with increases in OPEC production quotas, have resulted in Europe's share of OPEC exports falling from 30% in 1998 to 16% in 2012. Going back further, the decline is even more pronounced given that OPEC exports to Europe constituted 45% of total exports in 1986. Similarly, the percentage share of OPEC oil exports to North America has fallen from 28% in 2007 to 18% in 2012. The level and direction of OPEC oil exports has dramatically changed over the past decade, resulting in added importance of the Asian market segment to viability of OPEC.

ii. Market Penetration

While the previous section focused on the changing destination of OPEC exports, this section focuses on OPEC's market penetration from the import side. For the purpose of this study's analysis, segmented market penetration can be loosely defined as the percentage share that OPEC oil imports constitute of either a market segment's total oil imports or total oil consumption. Furthermore, market penetration for a segmented market will be used as a proxy for the market's degree of dependency on OPEC oil. From 2002 – 2012, OPEC imports as a percentage of world oil consumption rose from 22% to 28%. The most notable segmented increase has been in Asia where OPEC oil imports accounted for 49% of total oil consumption in 2012, up from 37% in 2002. OPEC's market share in North America has exhibited almost as impressive changes but in the opposite direction. Starting in 2007, OPEC's share of total North American oil imports began to decline, falling from 27% to 20% in 2012. Europe, Africa, and

Latin America all experienced relatively small variations in their dependency on OPEC oil within the context of the entire decade.[7]

For the purpose of analysis later, country case studies of the United States, China, and India will be presented. In the United States, OPEC imports as a percentage of both total oil imports and consumption have been declining dramatically since 2008. From 2008 – 2012, OPEC's market share of net US imports has fallen from 46% to 38%.[8] Additionally, OPEC imports constituted 31% of US consumption in 2008, but fell to 23% in 2012.[9] In sum, OPEC has been losing market share in the US for some time and that trend appears to be accelerating.

While the data sets for other countries are not as complete as those for the US, it is still apparent that China and India have been experiencing considerably increased dependency on OPEC oil. In China, OPEC imports as a percentage of net imports has been steadily increasing the past decade, rising from 34.7% in 2002 to 50.3% in 2012.[10] Similarly, OPEC market power in India has been increasing since at least 2009.[11] From 2007 – 2012, OPEC imports as a percentage of Indian net oil imports rose 5 percentage points, accounting for a staggering 78% of India's crude oil imports.[12] Both of these countries are heavily reliant upon OPEC oil imports, but the two countries face starkly different circumstances moving forward with respect to shale oil.

[7] See Appendix, Figure 7
[8] See Appendix, Figure 8
[9] See Appendix, Figure 9
[10] See Appendix, Figure 10
[11] Comprehensive and reliable data before 2007 was not available
[12] See Appendix, Figure 11

IV. Shale Oil

a. History and Properties of Shale Oil

The potential of shale oil has been apparent since as early as the 10th century when the Arabian physician, Masawaih al-Mardini, wrote of extracting oil from "some kind of bituminous shale."[13] For the next 1000 years, shale oil plays attracted varying degrees of interest from private and public entities, but to little avail. Shale oil formations consist of tightly-packed sedimentary layers of rock generally located deeper underground than conventional plays. In simple terms, conventional oil resources can be thought of as pools of oil located between layers of rock whereas unconventional oil (shale) is oil trapped in the small porous spaces of the layers of rock. Given the nature of shale formations, its development was originally hindered by two primary factors: 1. The absence of sufficient technology to effectively unlock oil from these tight formations, 2. Relatively low global oil prices made investment in its development financially impractical. Fast forward to 1981, George P. Mitchell began drilling in the Barnett Shale near Fort Worth, Texas. Over the next two decades he would be credited with honing horizontal drilling and hydraulic fracturing methods. Taken together with higher oil prices, Mitchell's revolutionary drilling practices would finally make shale oil recovery economically and technologically feasible, effectively unlocking billions of barrels of oil.[14]

b. Location of Shale Oil Reserves

Over the past decade, interest and exploration of shale resources has increased considerably. At least 137 shale formations with technically recoverable oil resources have been

[13] Forbes (1970)
[14] Martineau (2007)

discovered in over 41 countries.[15] According to the US Energy Information Administration (EIA), total technically recoverable shale oil reserves stand at approximately 345 billion barrels of oil, which constitutes an increase of 10.3% over existing conventional reserves. Given that shale development is still in its infancy, it is important to note that the EIA has chosen to be very conservative when estimating the potential of shale oil plays. For instance, the EIA approximates total US shale oil reserves to be 58.1 billion barrels, but one recently discovered play, the Cline Shale, has shown the potential to contain up to 30 billion barrels of oil.[16] Other recently discovered shales have shown similar potential, so it is possible that over time these reserve figures could go up significantly not only in the US but in other countries as well.

Geographically, two-thirds of these technically recoverable reserves are concentrated in six countries: Russia, U.S., China, Argentina, Libya, and Australia. It is of significance that only one OPEC member country, Libya, is among those countries with substantial shale oil reserves. [17] Also worth noting is that while China has large shale reserves available, the other large developing Asian economy, India, has no shale oil reserves of much significance.

c. Potential of Shale Oil Development

Significant development of shale oil reserves has occurred only in the past several years, the majority of which has occurred in the United States. The United States has increased shale oil production by 180% in the past three years from .82 mbopd in 2010 to 2.3 mbopd in 2013. [18] The EIA forecasts that trend to continue, albeit not as dramatically. Shale oil has undoubtedly been the primary driver of domestic increases in oil production in the past several years, accounting

[15] U.S. Energy Information Administration. *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*. (2013)
[16] Perryman (2013)
[17] See Appendix, Figure 21
[18] See Appendix, Figure 2

for 91.9% of increases in onshore oil production since 2010 and 33.7% of total oil production.[19] In fact, the International Energy Agency projects that the US will overtake Saudi Arabia and Russia to become the world's largest oil producer by 2016.[20] Outside of the US, however, only Canada is currently producing commercial amounts of shale oil.

At this stage of shale oil development, it is difficult to extrapolate the aforementioned trends seen in the US to other countries with shale reserves. This is due to primarily three reasons: 1. Shale oil plays are inherently unique geographically, even between distances of less than 1000 feet,[21] 2. There are a number of other factors which vary by country that influence the extent of shale development, such as capital availability, government regulation, economic incentive, etc.[22] 3. Higher costs of shale reserve developments make it markedly more sensitive to changes in in oil prices. Russia, for instance, faces particularly unique challenges in its largest shale formation, the Bazhenov, which is located in heart of Siberia and thought to contain perhaps the largest shale oil reserves on the planet. Due to the remote location and its unforgiving climate, the only way to access the Bazhenov is via helicopter in the summers. Winter time temperatures drop to below 40 degrees Fahrenheit, making development increasingly difficult.

Despite these obstacles, there is still great potential for shale oil production internationally, although it will likely take the form of a long-term development that will hinge on several of the factors previously discussed. In its long term forecast with high oil prices, the EIA projects that by 2040 global shale oil production will total nearly 8 million barrels of oil per

[19] U.S. Energy Information Administration. "Table: Oil and Gas Supply, High Oil Price." (2013)
[20] International Energy Agency (2013)
[21] Speight (2012)
[22] Wang and Krupnick (2013)

day, which is roughly the equivalent of adding another United States to the global oil supply mix.[23] Furthermore, the EIA projects shale oil production will constitute 8.4% of global oil production in 2040, up from 3.3% in 2013. In the United States, the EIA has, even in its high oil scenarios, consistently forecasted shale oil production levels below what would be observed, so there is a very high ceiling for unconventional oil production if countries like Russia, China, Argentina, etc. can replicate even to a lesser degree the success of US shale oil development. Currently, however, there are too many unknowns to justify projecting that same kind of success internationally. Regardless, the tremendous potential is clearly present and, in the next couple of years, stronger quantitative forecasts of international shale oil production should be available.

There are promising signs coming from a few governments with shale reserves. The Russian government, which historically has had particularly harsh oil tax policies, recently granted generous tax breaks to companies developing shale oil reserves, including a 100% mineral extraction tax break for developments in the Bazhenov. The United States had a similar tax policy in the early days of shale development as well as other government programs intended to spur unconventional resource development.[24] Programs like these are important to incentivizing the development of previously unexplored shale plays because, as mentioned earlier, every shale has distinct characteristics and until those characteristics are known it is difficult to achieve recovery rates that make shale development economically feasible.

[23] See Appendix, Figure 3
[24] Wang and Krupnick (2013)

V. Current and Prospective Impacts of Shale Oil on Segmented OPEC Market Shares

This section of the paper addresses the questions of what effect, thus far, shale oil has had on OPEC market shares and what impact it has the potential to create in the future. The proceeding analysis forecasts for significant shifts in segmented OPEC market penetration and discusses the potential shale oil has to reduce an otherwise growing Asian dependency on OPEC oil.

a. The World and Segmented Regional Markets

In the aggregate, the largely demand-driven changes in OPEC market shares seen over the last ten years will likely continue with larger and larger portions of its exports going to high-growth Asian economies. In fact, the International Energy Agency projects that by 2035 almost 90% of Middle Eastern oil exports will go to Asia, an economic partnership that has become known as the "new silk road."[25] However, shale oil presents a new paradigm on the supply side because for decades, Non-OPEC oil production was generally considered to be slowly declining in both the intermediate and long terms. An international shale revolution has the potential to significantly change the supply dynamics of oil markets, and this threat is not overlooked by those involved with OPEC. Saudi Arabian billionaire and oil developer, Prince Alwaleed bin Talal, has been particularly concerned, even writing a letter to the Saudi Oil Minister warning him of the potential of shale oil.[26] The International Energy Agency is also quoted as saying that the extraordinary growth of shale oil in the United States will produce a "sea-change in global energy flows."[27]

[25] International Energy Agency (2013)
[26] Said (2013)
[27] International Energy Agency (2013)

Since potential, from an international perspective, is largely all that shale oil comprises at this point, if we assume a conducive environment to shale development (i.e. high oil prices) and set up a simple model loosely defining demand for OPEC crude oil as the difference between world liquids consumption and total non-OPEC liquids supply,[28] there are significant intermediate-term changes in demand for OPEC oil. From a high of 36.2 mbpd in 2012, OPEC oil demand is forecasted to fall to 33.2 mbpd in 2016, a drop of 8.3% and 3 mbpd in just four years.[29] The primary contributor to this decline is shale oil development as it accounts for over 26% of increases in Non-OPEC supply.[30] After 2016, however, demand for OPEC imports and OPEC oil's global market share begins to grow as rises in consumption demand begins to outpace the arguably conservative estimates for increases in production. However, successful long-term development of shale reserves internationally has the potential to change that, given that US shale production increases are forecasted to be the primary driver behind the previously mentioned 8.3% drop in OPEC oil demand over the next four years.

While it is difficult to accurately project regional demand for OPEC oil imports specifically, it is useful to examine projected regional demand for oil imports as a whole. Once again, setting up a simple model that defines demand for oil imports as a region's consumption minus its production, we can forecast segmented demand for extra-regional oil imports.[31] Shale oil development, easily the primary factor behind increased production in North America, has a significant effect on OECD Americas' demand for oil imports. Through 2040, demand for oil imports in OECD Americas is forecasted to drop an average of 2.92% per year, including an average decline of 6.5% per year from 2010 – 2020. While consumption is projected to slowly

[28] Used by Alhajji and Huettner (2000)
[29] See Appendix, Figure 12
[30] U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." (2013)
[31] See Appendix, Figure 14

fall in the region, tight oil production increases far outpace the drop in demand, suggesting that it is the primary contributor to these declines in demand for oil imports.

In Non-OECD Asia, demand for oil imports is projected to rise significantly, averaging 6.5% per year through 2040. These rises are almost entirely demand driven since Non-OECD Asia oil production is forecasted to stay relatively constant in the intermediate-term while growing an average of 1.2% in the long term. The many unknowns concerning shale oil development make it difficult to confidently forecast for fully-realized shale oil production increases. However, the potential of shale oil in Asia is outstanding. The EIA estimates that the Asia region has shale oil reserves of 61 billion barrels, so there is certainly upside surrounding the Asia region's production forecasts. A prospective implication of large-scale shale oil development in Asia would be the weakening of what would otherwise be a growing OPEC market share. As will be discussed later, OPEC's market share in Asia is of particular importance.

b. The United States

OPEC has been steadily losing its share of US oil imports for decades, and that trend will likely continue. Using historical data of US oil imports from OPEC and total US oil imports, we can forecast future OPEC crude oil imports. After differencing the two time series to achieve stationarity, the following time series regression was created:

$$y_t - y_{t-1} = \alpha_0 + \alpha_1 (y_{t-1} - y_{t-2}) + \beta_1 (x_t - x_{t-1}) + \beta_2 (x_{t-1} - x_{t-2}) + \varepsilon$$

The above regression uses y, monthly OPEC crude oil imports from 1993 - 2013, as its dependent variable, and x, monthly total US crude oil imports from 1993 - 2013, as its independent variable. When forecasting, the model makes the assumption that future total US oil imports will mirror the US Energy Information Administration's projections for the metric. The

results of the regression can be seen in Appendix Figure 1. All of the variables were statistically significant at the 99% confidence level, and the resulting model had an adjusted-R square of .7623. As is often discussed in current news, the subsequent parameter estimates of the regression variables suggest that the US is indeed focused on reducing oil imports from OPEC specifically. If the trend holds, OPEC will be a facing significantly weakened market share in the United States over the coming decades.

Using monthly projections of total US oil imports through 2040, a forecast of US oil imports from OPEC was created. The resulting data of the projection showed a continuing of the downticks in both OPEC oil imports volumetrically and OPEC imports as a percentage share of total imports. From 2013 – 2040, US oil imports from OPEC are forecasted to decline an average of 3.27% per year and a total of 3.61 mbopd.[32] Furthermore, OPEC's share of total US oil imports is forecasted to fall from 38.7% in 2013 to 7.2% in 2040.[33] If we assume that imported oil demand is solely driven by total consumption and production, then it is apparent that these changes are largely production driven since US consumption is only expected to decrease an average of .2% per year through 2040. Among future US supply drivers, shale oil is easily one of the most significant, averaging a growth rate of 2.1% per year, with figures much higher than that in the intermediate-term. The importance of shale oil is especially pronounced when compared to the .6% projected average growth rate of total US oil production. This lower forecasted growth rate of total US production is driven by large decreases expected in conventional and Alaskan oil production. Should production levels from these two sources be

[32] See Appendix, Figure 15
[33] See Appendix, Figure 16

held constant,[34] the ultimate effects of shale oil on OPEC imports would be even more pronounced.

c. China

Due to lack of data, a similar regression could not be completed for Chinese and Indian demand for OPEC oil. In China, however, if we once again create a simple model that assumes China's demand for imported oil to be its oil consumption minus its production, then we forecast a couple of trends.[35] Total imported oil demand in China is expected to rise an average of 29.27% per year and a total of 8.78 mbopd through 2040. As would be expected, oil consumption growth in China is forecasted to be very strong, driving demands for imported oil consistently upwards. In the short-term, Chinese oil production is forecasted to stay relatively flat at around 4.4 mbopd. In the intermediate and long terms, oil production in China is expected to rise, increasing by an average of 4.1% per year from 2020 – 2040 and slowing the growth in the gap between imported oil demand and production. However, it is a likely possibility that OPEC market share in China will still be rising in the future given that increases of OPEC imports have covered anywhere from 38% to 69% of increases in total Chinese imported oil demands since 2003 and appear to be on a rising trend.[36] If we assume OPEC imports to continue providing for that range of increases in total imported oil demand, then OPEC imports to China could rise anywhere from 3.34 mbopd to 6.06 mbopd by 2040.

While it was not possible to obtain a break-down of the forecasted growth in Chinese oil production, it is likely that existing conventional reserve development is the primary driver of

[34] A reasonable assumption in many countries outside of the US that have conventional reserves that are not as fully developed
[35] See Appendix, Figure 17
[36] United Nations Publications Board (2013)

increases due, once again, to the unknown nature of shale reserve development outside of the US. If successfully extracted, shale oil in China could easily be a very important factor in China's future supply increases, especially considering its large amount of shale oil reserves relative to conventional reserves. In fact, shale reserves have increased total oil reserves in China by 126%, compared to an increase of 10.3% for the world.[37] Since developing shale reserves is more expensive than conventional reserves, it would be reasonable to expect China to first focus on fully developing existing conventional reserves. However, should China place a strong focus on decreasing dependency on foreign oil imports, its growing economy would likely rapidly absorb production increases from the country's few remaining undeveloped conventional plays, ultimately meaning that shale reserves could quickly become the major driver in China's domestic production increases. The important point to note when comparing China to India is that China has shown the capacity in the past to develop its conventional reserves,[38] and, now, with an additional 32.2 billion barrels of reserves in the form of shale oil, it has the potential to continue development on a much larger scale.

d. India

India faces a very similar situation, consumption-wise, to China, but otherwise their circumstances in the intermediate and long run are exceptionally different. Forecasts for future Indian oil production could not be attained, but projections of oil consumptions are telling. From 2013 – 2040, oil demand in India is forecasted to grow at a rate of 3.7% per year and a total of 5.9 mbopd.[39] On the supply side, growth in Indian oil production has been incredibly stagnant,

[37] U.S. Energy Information Administration. *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*. (2013)
[38] See Appendix, Figure 18
[39] See Appendix, Figure 19

especially in recent years. Indian oil production has averaged increases of 1.6% per year since 2005, adding a total of only .22 mbopd.[40] From 2009 – 2012, that already meager growth slowed to .008% per year. While increased future growth in Indian oil production is still expected, it will occur only on a limited scale. India has shale reserves of 3.8 billion barrels and existing conventional oil reserves of 5.4 billion barrels, figures that are dwarfed by China's 57.8 billion in combined shale and conventional reserves.[41]

India, already heavily reliant on OPEC crude, faces a difficult situation covering the 5.9 mbopd increase in consumption over the next few decades. Given India's lack of reserves in general and a history of particularly poor oil development, it is very likely that the vast majority of increases in consumption will be met with OPEC oil imports. In 2012, OPEC imports accounted for 78% of total Indian crude oil imports, and that share is set to rise. Going off the limited data available, increases in OPEC imports have made up anywhere from 74% to 95% of yearly increases in Indian imported oil demand from 2007 – 2012, the 95% occurring in 2012.[42] If this trend holds, anywhere from 4.37 mbopd to 5.61 mbopd of the 5.9 mbopd increase in Indian oil demand will be met with OPEC imports, intensifying India's already vital dependency on OPEC oil and raising some important geopolitical questions as well.

In sum, the simple model used to forecast OPEC imports projects that OPEC imports continue to account for a large portion of global oil consumption, albeit decreasing in the intermediate-term. However, the data used in this model placed little to no value on future production from shale oil internationally. If other countries can replicate the success of US shale

[40] See Appendix, Figure 20
[41] U.S. Energy Information Administration. *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*. (2013)
[42] United Nations Publications Board (2013)

development, there is no reason to believe that the shale-driven intermediate term decrease in demand for OPEC oil could not be extended. In the countries of China and India, the potential effects of shale oil are especially pronounced. China has the third largest shale oil reserves in the world, and, should it choose to aggressively develop them in the future, there could very well be significant negative implications for OPEC's market share in the country. There is also a strong strategic incentive for countries to diversify its sources of oil imports. Among other things, this strategic incentive is driven largely by geopolitical reasons but also by a country's desire to avoid exposure to the OPEC "oil weapon."[43] In this context, the early effects of shale oil can already be seen in Algeria and Nigeria where crude oil imports to the United States from January of 2011 to August of 2013 have fallen 81.4% and 83.7% respectively.[44] If we hold the assumption that OPEC-dependent countries like China and India are incentivized to diversify oil imports, then we can conjecture that shale oil production in already net-exporting countries (e.g. Russia) will allow those countries to increase their oil exports. Furthermore, those exports will generally be preferred over OPEC exports, perhaps giving added incentive to countries like Russia, Argentina, etc. to develop shale reserves. At this point, only the potential of shale reserves can be considered outside of the US. Given its location and massive size, shale oil clearly stands as the principal threat facing OPEC market shares, especially in Asia.

[43] Mityakov, Tang, and Tsui (2011)
[44] U.S. Energy Information Administration. "Table: US Imports from OPEC Countries of Crude Oil and Petroleum Products." *Petroleum & Other Liquids*. (2013)

VI. Potential OPEC Responses to Shale Oil Development

This section of the paper analyzes the following question: if shale oil development begins to realize its full potential internationally, what response would OPEC have and what would be the accompanying implications of its response. The following game theory analysis will show that, in a perfectly collusive situation, OPEC has the capacity to hinder shale oil development, and, in an imperfectly collusive situation, OPEC's ability to effectively respond to prospective shale production is severely limited. Ultimately, this section concludes that the more realistic likelihood of an imperfectly collusive response will most likely have little to no effect on the development of shale oil.

a. OPEC's Motivation

To speculate as to what response OPEC would have to significant shale oil development internationally, we must first fully understand their reasons for acting. The perception that there exists an already weak economic incentive for OPEC producers to collude is supported by several points. As discussed previously, there have been significant recent shifts in the level of OPEC market power by market segment, and a continuation of these trends is forecasted.[45] Additionally, there is a strong argument for oil not being entirely fungible in the short-term,[46] so it is plausible that OPEC could translate these future increases in segmented market share into short-term pricing power in certain circumstances. However, in the intermediate and long terms, oil is largely fungible,[47] and, as numerous analyses have shown, OPEC's large market shares have not translated into significant pricing power.[48] In fact, Granger Causality tests on OPEC

[45] See Appendix, Figures 7, 14, 15, 17, and 19
[46] Mityakov, Tang, and Tsui (2011)
[47] Adelman (1984)
[48] Li (2010)

production, aggregate Non-OPEC production, and refiner acquisition cost of imported crude oil (RAC)[49] showed not only that OPEC production did not exhibit a causal effect on RAC, but that the trail of causation runs from Non-OPEC production to oil price to OPEC production.[50] This ineffectiveness is manifested in OPEC member countries' adherence to production quotas. There have been a large number of studies that have analyzed whether or not OPEC member countries cheat on production quotas. For the most part, all the studies arrive at the same conclusion: many OPEC members countries cheat.[5152] Their reasons for cheating are based partly on the previously discussed ineffectiveness of OPEC, but they are also motivated to cheat because of a lack of trust, potential competition, the future risk of technological substitutes for oil, and the difficulty of coordinating in a game.[53]

If the economic incentive to collude is weak, then it would appear that OPEC has little reason to still exist. However, the political power wielded by the "oil weapon" plays a large role in OPEC's continued existence. According to Wirl (2009), this prospective political weapon is a crucial incentive that motivates member countries to remain a part of OPEC, though that does not necessarily mean that they abide by production quotas during times of political tranquility. Originally used as a political lever against the West,[54] the aforementioned forecast of US dependency on OPEC oil legitimately weakens the direct effectiveness of that lever, particularly on North America. Instead, in the future, the most vulnerable victim of OPEC's potential "oil weapon" will likely be Asia, considering the region's appreciable forecasted rises in oil consumption and OPEC imports. Given that Asia is also forecasted to be the principal engine of

[49] Used as a representative price of crude oil
[50] See Appendix, Figure 22
[51] Pippenger and Reynolds (2010)
[52] Li (2010)
[53] Pippenger and Reynolds (2010)
[54] Examples include the Yom-Kippur war in 1973, the Iranian revolution and its aftermath 1979/80, the Iraq–Iran war, the liberation of Kuwait, and the Iraq war. BP (2008)

economic growth and the high degree of globalization in modern economies, an extensive amount of political influence over Asia can indirectly translate to a certain degree of political influence over the West, including North America and the United States. For those reasons, the proceeding analysis of OPEC responses will assume that the primary motivation of OPEC and its producers is to maintain Asian dependency on OPEC imports and, thus, the influence of its "oil weapon."

b. Perfect Collusion Scenario

The following two analyses of potential OPEC responses are, in the absence of statistical forecasts for fully-potentialized shale oil internationally, qualitatively discussed under the assumption that the development of large shale reserves in China, Russia, Argentina, etc. begin to pose a threat to the validity of OPEC political influence. Furthermore, this particular analysis assumes a perfectly collusive OPEC cartel where all members are fully committed to the organization's mission to maintain a level of market share in Asia and, consequently, members abide by set production quotas. In the situation that at some point in the future shale reserve development in Asian countries and competing oil-exporting countries begins to pose a threat to OPEC political power, OPEC would have three basic options: 1. Maintain business as usual, 2. Flood the market to deem shale development economically infeasible, or 3. Cut production to realize short-term gains as a fully profit-maximizing cartel. The practicability of each option would be highly dependent on numerous factors, such as where and to what degree is the potential of shale development, oil demand growth, OPEC segmented market share, OPEC spare capacity, geopolitical affairs, etc. Considering the many unknowns, each of OPEC's options will be analyzed by what conditions would need to be present to make the particular option a prudent route with a specific focus on the scale of shale development and, assuming those respective conditions, what effect the decision would have.

i. Option 1: Maintain Business As Usual

Regarding the first option, the feasibility of maintaining business as usual would require conditions similar to those presently. Shale development would need to occur on a relatively small scale, preferably concentrated in currently net oil-importing countries (e.g. present day United States). It is possible that China could play this role, but, as long as shale oil development is occurring on a small scale, the large forecasted increases in China's oil consumption would help cancel out any notable effects on OPEC market share in China. Similarly, relatively small increases in shale oil production from Non-OPEC net oil-exporting countries (e.g. Russia, Argentina, etc.) would certainly be an unwanted problem for OPEC, but the notable forecasted demand increases in Asia would stymie any significant impacts. The effect of OPEC maintaining business as usual in this circumstance is rather self-explanatory. OPEC member countries would continue to produce at set quotas, and the political influence of OPEC would remain largely unchanged due, once again, to substantial increases in Asian oil demand. Should substantial shale development be occurring, this option offers OPEC the ability to slowly lose it's a power as a political entity rather than hastening the process, as would be the case in the third option.

ii. Option 2: Flood the Markets

Given the higher cost of shale development, the second option OPEC has is to flood the market with oil, lowering prices to a point where shale oil development is no longer economically feasible. The prime condition for this route to be considered is shale development happening on a very large scale. The most idealistic situation for this option to be taken includes several other conditions. First, significant shale development would preferably be occurring largely in Non-OPEC net oil-exporting countries. This is because the effect of lower oil prices

would have acutely negative consequences for net oil-exporting countries like Russia, whose economies are generally heavily dependent on oil. Second, shale development would be, to some extent, technically or economically hindered in Asian countries. There is a strategic incentive for countries to diversify its sources of oil,[55] so deeming shale development infeasible for the private sector or NOCs[56] in net-exporting countries does not necessarily mean shale development would not be prudent for NOCs in net-importing Asian countries. Furthermore, Asian economies would likely reap the benefits of cheaper oil, meaning the possible increases in capital availability would have the potential to spur shale development by NOCs. Third, OPEC would have the spare capacity to cause the necessary drop in oil prices. The effectiveness of this option is exceptionally dependent upon how low OPEC would need oil prices to drop and whether or not OPEC has the spare capacity to make that happen. Fourth, the economic incentive of reducing the impact of shale oil would be great enough to make up for sustained lower profit margins per barrel, faster rate of reserve depletion, and so on and so forth.

Assuming these idealistic circumstances, on top of dealing net oil-exporting economies a macro-economic blow that could reduce capital availability, flooding the market with oil would reduce the incentive to develop higher-cost shale oil.[57] OPEC producers would "open up the valve" to lower oil prices, and, to avoid the possibility of the price reduction being just a short term setback for shale development, they would adjust production accordingly over the long term. By flooding the market in these conditions, OPEC would effectively marginalize the prospect of shale development having an effect on its share of Asian oil imports. However, should OPEC not possess the needed spare capacity, this option would be entirely ineffective.

[55] Mityakov, Tang, and Tsui (2011)
[56] NOC stands for National Oil Companies which are government-operated publicly funded exploration companies among other things
[57] Though the break-even price for different shales varies significantly

Additionally, if Asian countries possessed the capability to drill shale or had significant shale developments already in the works, flooding the market could be unproductive and have unintended consequences in the form of stimulating Asian economies with cheap oil.

iii. Option 3: Cut Production

The third option OPEC would have is to cut supply to the point where OPEC is operating as a fully profit-maximizing cartel,[58] effectively reaping short term gains at the expense of further incentivizing shale oil development. Once again, the major condition for this option to be considered substantial development of shale reserves, and the idealistic scenario would involve a couple of other specifications. First and foremost, there would need to be the perception by OPEC members that shale oil development and the consequential weakening of their "oil weapon" is inevitable, and that their decision to capitalize on short term financial gains would make up for the sacrifice of long term political power. The perception of shale development being inevitable could be motivated by numerous factors including an overtly massive-scale of shale development, adequately high oil prices and/or low spare capacity that render the second option of flooding the market impractical, a high degree of motivation in Asian countries to diversify oil sources, etc. Second, a large portion of the shale developments would preferably be located in Asian countries as opposed to the countries of competing net oil-exporters. This is because cutting supply to raise oil prices could hurt Asian economies heavily dependent on oil exports, possibly decreasing capital availability and to some degree hindering shale development. On the other hand, a spike in oil prices would certainly benefit net oil-exporting

[58] Evidence suggests that business as usual for OPEC has not been the behavior of a profit-maximizing cartel. Alhajji and Huettner (2000)

countries which, if they constituted a large share of potential shale developments, could seemingly intensify drilling of shale reserves.

If we assume this idealistic situation, OPEC members would decrease supply to the point that OPEC would be a fully profit-maximizing cartel. However, this would come with the price tag of a decrease in political power and the possibility of further incentivizing shale development, depending especially upon where shale developments are taking place. Regardless, by cutting supply to sufficient levels, OPEC member countries would enjoy greater financial gains at least in the short-run. In the long-run, this option has many more unknowns. The successful long-term development of shale would leave the OPEC "oil weapon" at best highly marginalized. If we assume the political power of OPEC to be the primary force binding its member countries, then the incentive behind continued membership would decay over time, possibly to a point where dissolution could be an issue.

In sum, in the case of relatively insignificant shale development and sufficiently large OPEC spare capacity, OPEC would have the opportunity to pursue any of the three options, though the first option of maintaining business as usual appears to be the most probable. In the case of substantial shale development and adequately large OPEC spare capacity, OPEC could also pursue any of the three options, but it is currently unclear as to which option would be the most prudent. Lastly, in the case of large-scale shale development and insufficiently large OPEC spare capacity, OPEC would be faced with deciding between continuing business as usual or cutting supply to capitalize on the short term gains of operating as a perfectly profit-maximizing cartel. This decision would ultimately rely upon the perception of the significance of shale development in the future, as well as the importance OPEC places on short term financial gain,

as would be the case in the third option of cutting supply, versus a more intermediate term extension of its political power in the case of maintaining business as usual.

c. Imperfect Collusion Scenario

i. Option 1: Maintain Business As Usual

In the scenario of imperfect collusion, the practicability of maintaining business usual remains relatively unchanged. As discussed previously, business as usual for OPEC has been a loose collusive agreement where production quotas are set but generally not followed by many producers. In the case of relatively insignificant shale development, maintaining business as usual would likely result in little change to OPEC market share in Asia due to fast-rising oil consumption in the region. However, quickly-rising demand for oil in Asia could give some producers the incentive to further stray from their production quotas in the hopes of achieving greater penetration into a market that is forecasted to be major demand driver in the future.

In the situation of substantial development of shale reserves, the incentive for OPEC producers to maintain the status quo changes. Significant development of shale oil taken together with OPEC maintaining production quotas would lead to the expectation by member countries that OPEC's political power would eventually be declining as shale production from competing oil exporters penetrates the Asian markets.[59] Additionally, ensuing rises in oil production driven by shale would be expected, and, ceteris paribus, this would lead OPEC member countries to also expect a decline in future oil prices. So, if member countries expect OPEC political influence to inevitably begin decaying and oil prices to be relatively lower in the future, a member country's decision to stray from production quotas is further incentivized.

[59] Once again assuming that there is strategic incentive for OPEC-dependent Asian countries to diversify its sources of oil. Mityakov, Tang, and Tsui (2011)

However, according to game theory, there would be decreased incentive to this position. This is caused by a member country's expectation that other OPEC producers foresee the same future changes and would also have a greater motivation sell more of their oil which, if acted upon, would mean a near-term spike in supply that would drive down oil prices, generally leaving everyone worse off. A lack of trust has certainly played a factor in OPEC members deviating from production quotas in the past, but rarely have many member countries substantially deviated from production quotas at once perhaps driven in large part by the prospect of continued OPEC political power. Nevertheless, the conceivable expectation of sustained declines in OPEC political influence has the potential to serve as a tipping point that motivates member countries to substantially deviate from their production quotas.

The extent or even existence of this added incentive to cheat on production quotas depends on a number of things, including the scale of shale development, a member country's spare capacity, availability of and competition for buyers of a country's exports, etc. If the conditions were conducive and the threat to future OPEC political power was great enough, the effect, to some degree, would likely be increased deviation from production quotas that cause short-term drops in oil prices. In the long-run, it is possible that either some equilibrium would be found or OPEC producers would continue to wildly stray from quotas. There are too many unknown variables to confidently speculate. What is certain, however, is that choosing to maintain business as usual combined with successful long-term development of shale oil would mean a slow decline in the power of OPEC's "oil weapon."

ii. Option 2: Flood the Markets

The second option for OPEC is to flood the oil markets with the hopes of rendering shale developments economically infeasible. The conditional requirements for this plan to be considered would be significant shale development, adequate OPEC spare capacity, and sufficient economic incentive. If we assume these three conditions to be present, then there would be very strong incentives for OPEC members to collude. There would be an motivation for member countries to collude to hinder the development of shale reserves which would have the possibility of negative long term consequences on oil prices. Additionally, there would be an incentive to collude to maintain the power of OPEC as a political entity. Given that Saudi Arabia easily controls the major share of OPEC spare capacity, the only possible disincentive to colluding would be in the situation where other OPEC producers were not crucial to the effectiveness of the plan. This could incentivize a member country to keep production at current levels, avoid depleting their reserves, and essentially let Saudi Arabia do the work. Even this incentive comes with a down side though as not increasing production in a prospectively lower oil price environment would mean lower revenues for a non-participating OPEC government who would likely be highly dependent on those oil revenues. However, the strong incentives for colluding would likely still result in OPEC member countries choosing to collude and flooding the market with the necessitated amount of oil to hamper the development of shale.

iii. Option 3: Cut Production

If shale development is viewed as inevitable due to high oil prices, insufficient spare capacity, exceptional desire in Asia to diversify oil sources, etc., then the third option OPEC could consider is cutting supply to a point where it is fully profit maximizing. However, in an imperfectly collusive environment, this is not likely to be practical. As discussed earlier, numerous research papers have shown that OPEC does not operate as a profit-maximizing cartel

and that attempts to cut production quotas have resulted in cheating by member countries. This situation is no different. There would be incentive for a member country to not collude because by cheating when other countries do not they would be able to enjoy higher oil prices and more production. Game theory would suggest rational member countries realize that, if acted upon, this universal disincentive to collude would leave everyone worse off, leading to a collusive incentive. Empirically, however, a lack of trust, monitoring, and a punishment mechanism for deviating from production quotas have been the primary causes of continued cheating from OPEC producers. Furthermore, assuming the primary incentive for member countries to remain in OPEC is OPEC political power, lowering production would be even more impractical as it would likely significantly reduce OPEC political influence. The only circumstance where collusion would appear to be remotely possible is if the prospect of shale development was seen as exceptionally substantial and likely to occur largely in the short run. Then, member countries would be faced with weighing the advantages of short term political power against short term financial reward. Even then, however, the uncertainty of the obvious choice between the two could create trust issues among OPEC member countries that would further support the incentive to not collude.

The most probable outcome of this option to cut production levels would be a regression to business as usual that includes little adherence to production quotas. There would be too many incentives to cheat and too few controls. A continuation of business as usual would involve, as discussed earlier, OPEC political influence slowly decaying with the assumed long-term success of shale development.

In sum, in the cases of both relatively small and large shale developments, the most likely result in an imperfectly collusive environment would be a continuation of business as usual.

Only in the specific situation of significant shale development, adequate OPEC spare capacity, and sufficient economic incentive would a collusive OPEC decision to flood the market appear possible. While there are many unknowns associated with the preceding analysis, the fundamental implication of fully-realized shale oil development can still be said with some degree of certainty to be an eventual deterioration of OPEC political influence in Asia.

VII. Conclusion

The key finding of this paper is that shale oil development has the potential to detrimentally alter OPEC market shares particularly in Asia and, thus, marginalize the power of OPEC's "oil weapon."

To arrive at this conclusion, the foundational analysis centered on building simple models and using gathered data to predict future segmented demand for oil imports. This initial analysis ultimately concluded that the Asia region is easily the primary source of forecasted increases in imported oil demand, and, in the absence of substantial future shale development, OPEC is poised to expand its market share in the region. In the United States, an even more quantitative forecast was carried out employing a time series regression of monthly US imports from OPEC and total US oil imports. This forecast found that imported oil in the US will fall by 3.27% per year and 3.61 mbopd by the end of 2040. Furthermore, OPEC's market share of total US oil imports is set to fall to 7.2% in 2040 from 46% in 2008, demonstrating the potential shale development possesses. A focused analysis on the countries of China and India was then carried out, using another simple model to forecast imported oil demand. The conclusion of this analysis was that both China and India have rapidly rising demand for oil imports, but only in China do large reserves afford it the ability to eventually reduce dependence on imported oil. The selection of the three country case studies was done to contrast the respective implications of shale oil for the different countries. In the United States, shale oil has already begun to lessen the US's dependence on OPEC oil and set it on the path towards energy independence. In China, shale reserves have yet to be developed, but they afford China the opportunity and security of possible increases in domestic oil production. Lastly, in India, a complete lack of significant shale

reserves and growing consumption has left India more vulnerable and dependent than ever to OPEC.

After building a foundation for additional analysis, an evaluation of contemporary studies was then conducted to determine the motivating factors for OPEC producers. The research on this issue concluded that there is little economic incentive for OPEC producers to remain in OPEC. Rather, the political power wielded by OPEC's "oil weapon" was the primary binding force of OPEC countries. Since preceding analyses concluded that OPEC market power in the US was declining and already OPEC-dependent Asia was poised to become even more dependent, it was determined that the US shale revolution had in large part caused a refocusing of the "oil weapon" to the Asia region. After establishing this, a game theory analysis was carried out. This analysis included a qualitative discussion of OPEC and member countries' incentives and responses in the situation where shale oil reserves are beginning to be developed on a sufficiently large-scale to threaten OPEC's market share in Asia and, thus, its political influence. The study concluded that in a perfectly collusive scenario OPEC could potentially thwart shale development given a specific set of circumstances. More likely though would be either a slow decay in OPEC market share from maintaining business as usual or a more rapid deterioration in OPEC market share resulting from cutting production to operate as a fully profit maximizing cartel. In the more probable scenario of imperfect collusion, OPEC responses were much less effective. In the vast majority of situations, OPEC member countries had the incentive to cheat and a regression to business as usual and a steady decay in political power appeared most likely. While it depends on many future conditions, the fundamental conclusion drawn from the game theory analysis was that, in the more plausible case of an imperfectly colluding OPEC, the cartel would be highly ineffective at hindering a large-scale rise in shale development

unless very specific circumstances were present, leading to gradual reductions in the power of OPEC as a political entity.

In this paper, the implications of an international shale revolution were primarily discussed from a qualitative stand point due to the many unknowns concerning shale development globally. As shale production progresses in countries outside of the United States, a more quantitative analysis of shale implications will be possible. Until then, however, this paper has found that substantial international shale developments has the potential to significantly impact OPEC market shares in Asia, and, furthermore, an OPEC response would likely be ineffectual. The resulting decrease in Asian market shares would marginalize OPEC's "oil weapon" which, among other things, would reduce the incentive for member countries to continue OPEC membership.

VIII. Appendix

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	1.08497E10	**DFE**	241
MSE	45019346	**Root MSE**	6710
SBC	5030.7896	**AIC**	5016.78457
MAE	5220.95985	**AICC**	5016.95124
MAPE	163.291832	**HQC**	5022.42439
Durbin-Watson	2.0320	**Regress R-Square**	0.7623
		Total R-Square	0.7623

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	-264.1928	428.9154	-0.62	0.5385
ydif_1	1	-0.2741	0.0621	-4.42	<.0001
xdif	1	0.4741	0.0203	23.31	<.0001
xdif_1	1	0.1271	0.0359	3.54	0.0005

Figure 1: Regression Analysis of total US Oil Imports and US oil Imports from OPEC

Sources: U.S. Energy Information Administration. "Table: US Imports from OPEC Countries of Crude Oil and Petroleum Products." *Petroleum & Other Liquids.* (2013) and U.S. Energy Information Administration. "Table: US Imports of Crude Oil and Petroleum Products." *Petroleum & Other Liquids*. (2013)

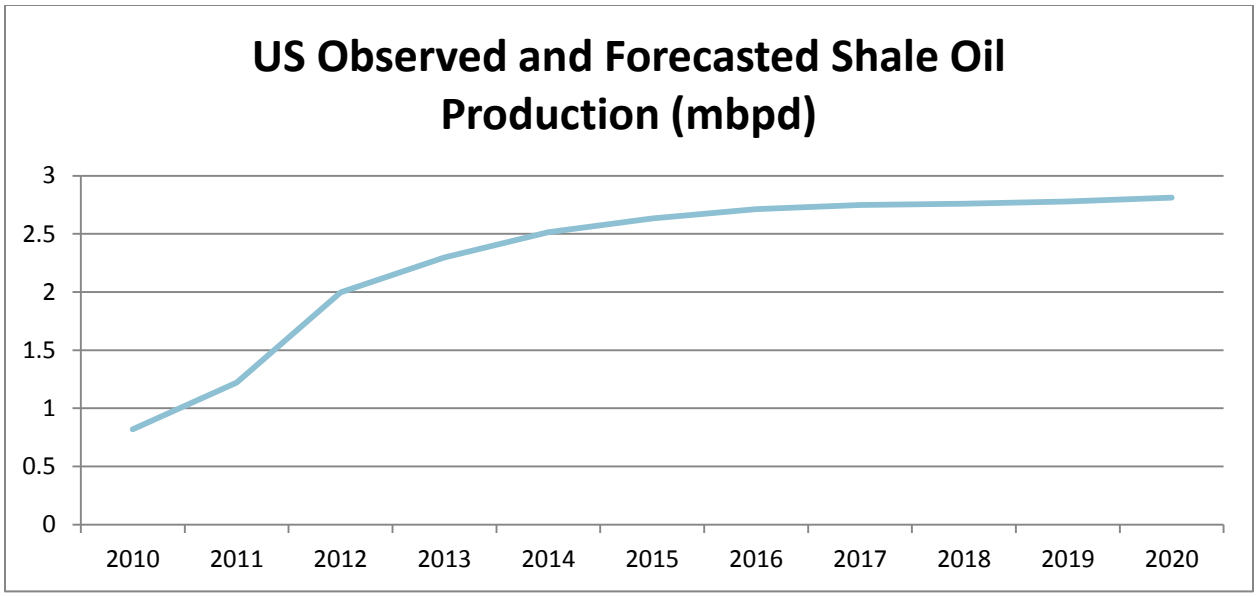

Figure 2: US Observed and Forecasted Shale Oil Production

Source: U.S. Energy Information Administration. "Table: Oil and Gas Supply, High Oil Price." ***Annual Energy Outlook 2013***

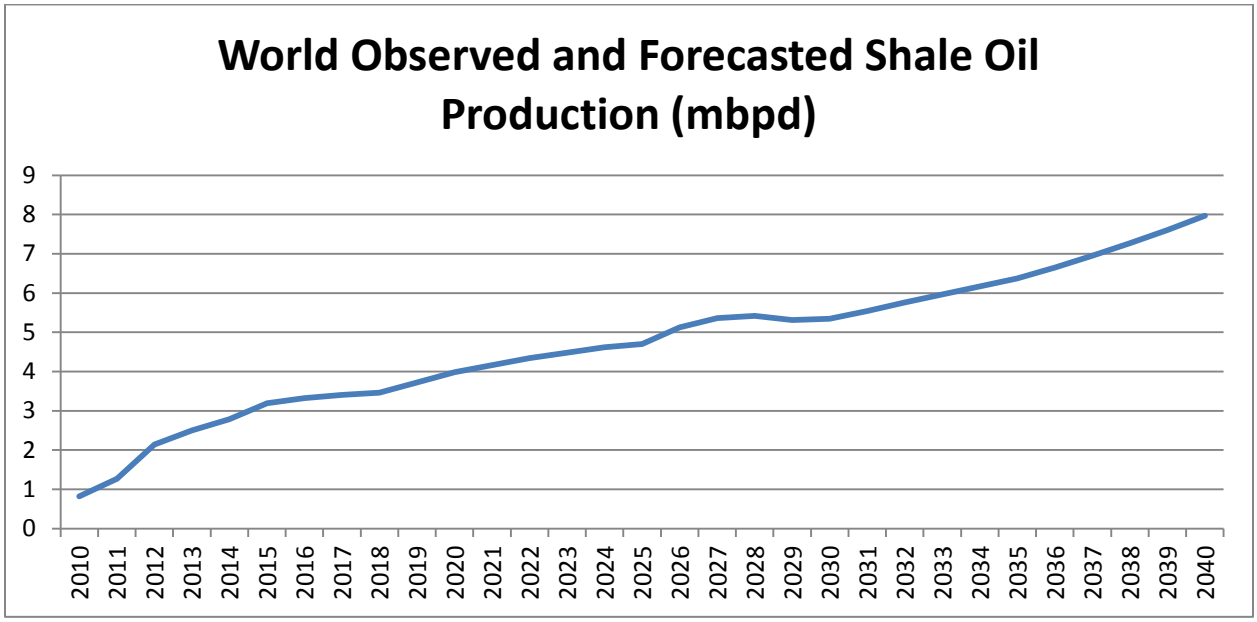

Figure 3: World Observed and Forecasted Shale Oil Production

Source: U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." ***Annual Energy Outlook 2013***

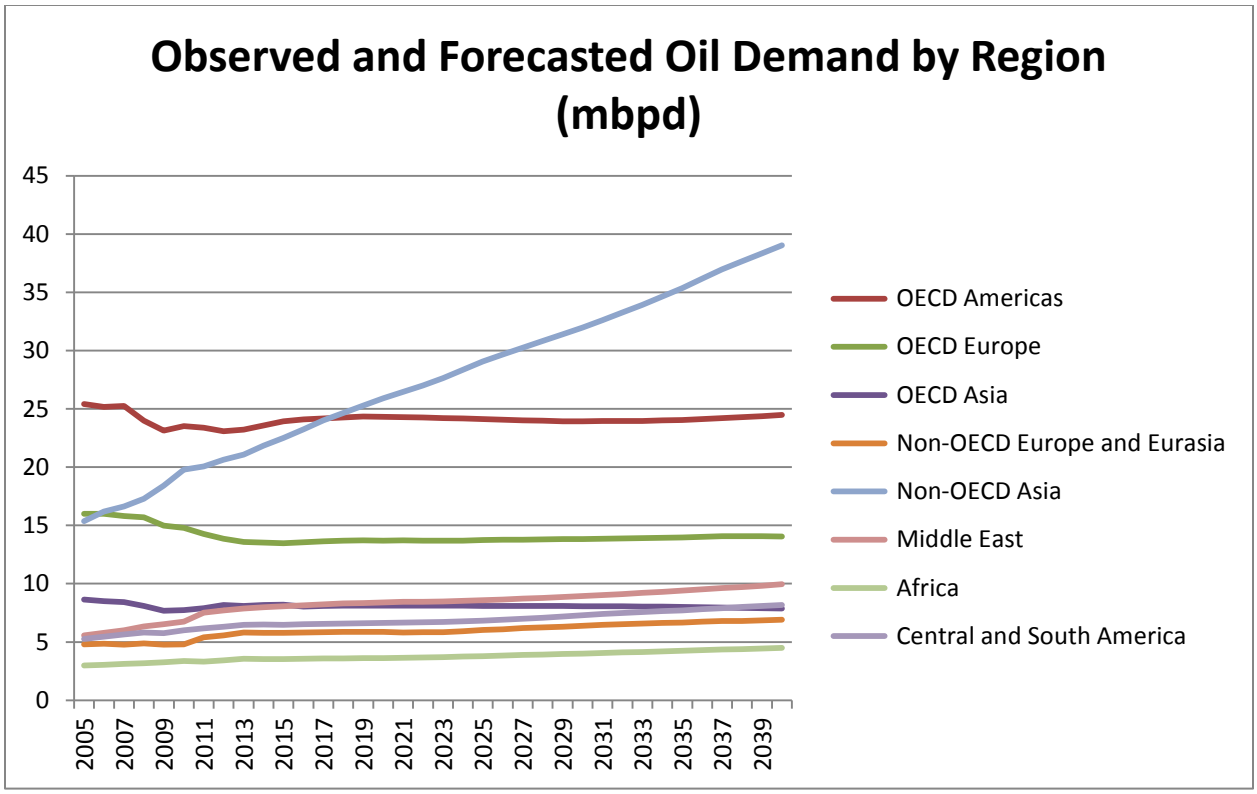

Figure 4: Observed and Forecasted Oil Demand by Region

Source: U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." ***Annual Energy Outlook 2013***

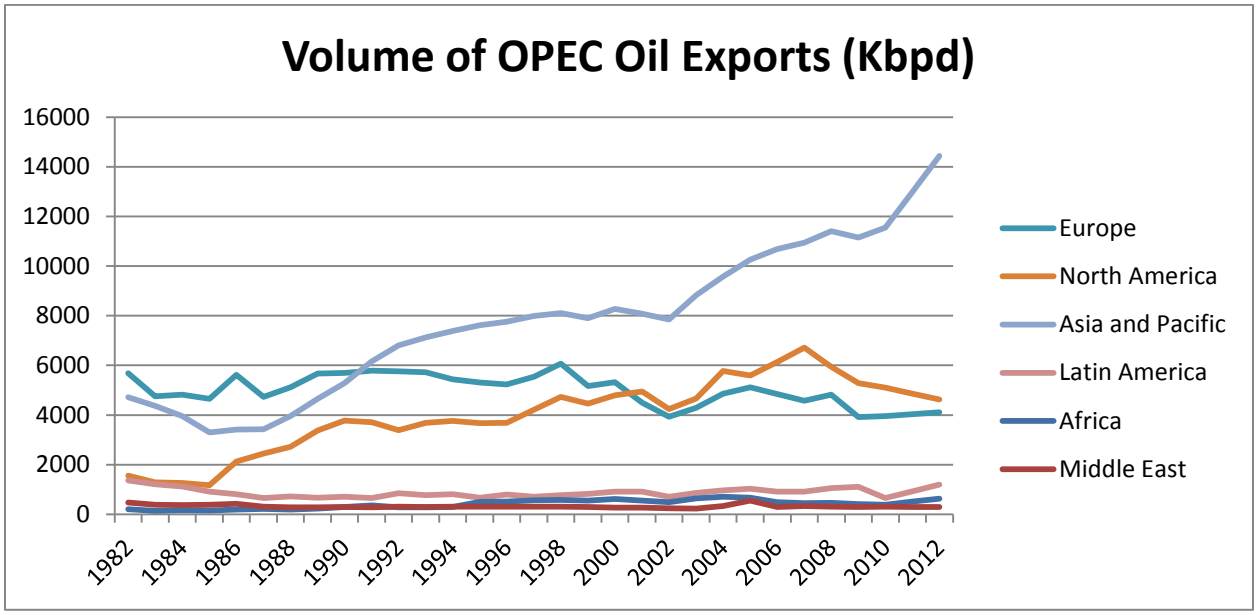

Figure 5: Volume of OPEC Oil Exports

Source: Organization of the Petroleum Exporting Countries. *OPEC Annual Statistical Bulletin*. (1999, 2002, 2007 and 2013)

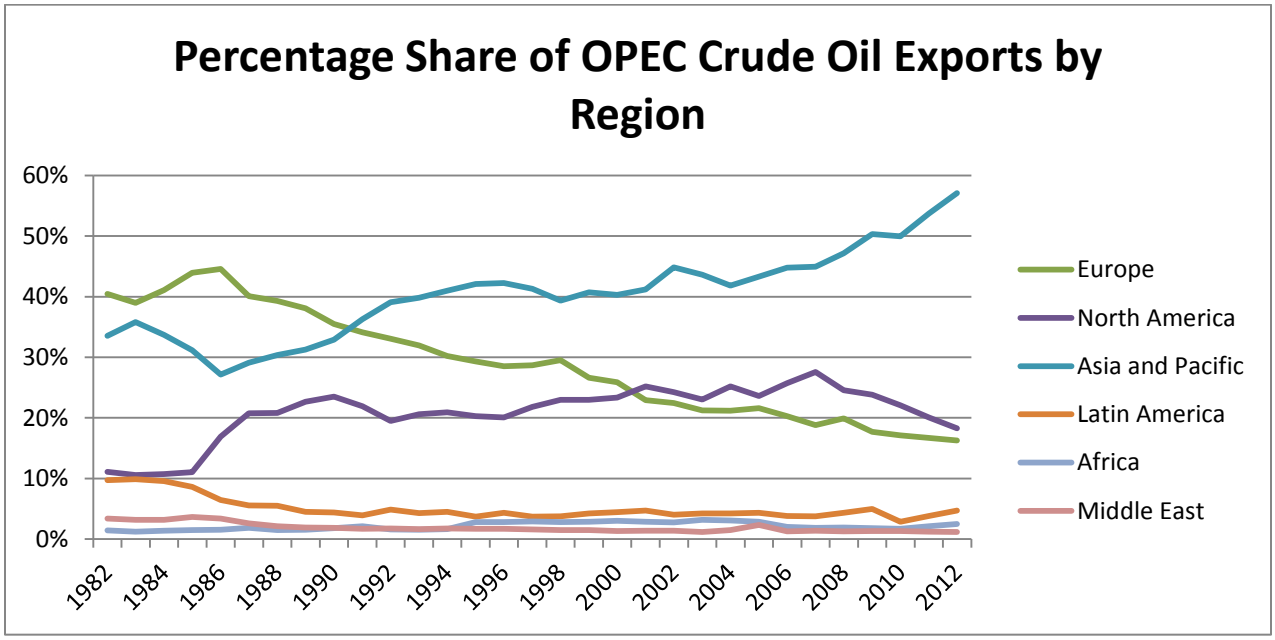

Figure 6: Regional Share of OPEC Oil Exports

Source: Organization of the Petroleum Exporting Countries . *OPEC Annual Statistical Bulletin*. (1999, 2002, 2007 and 2013)

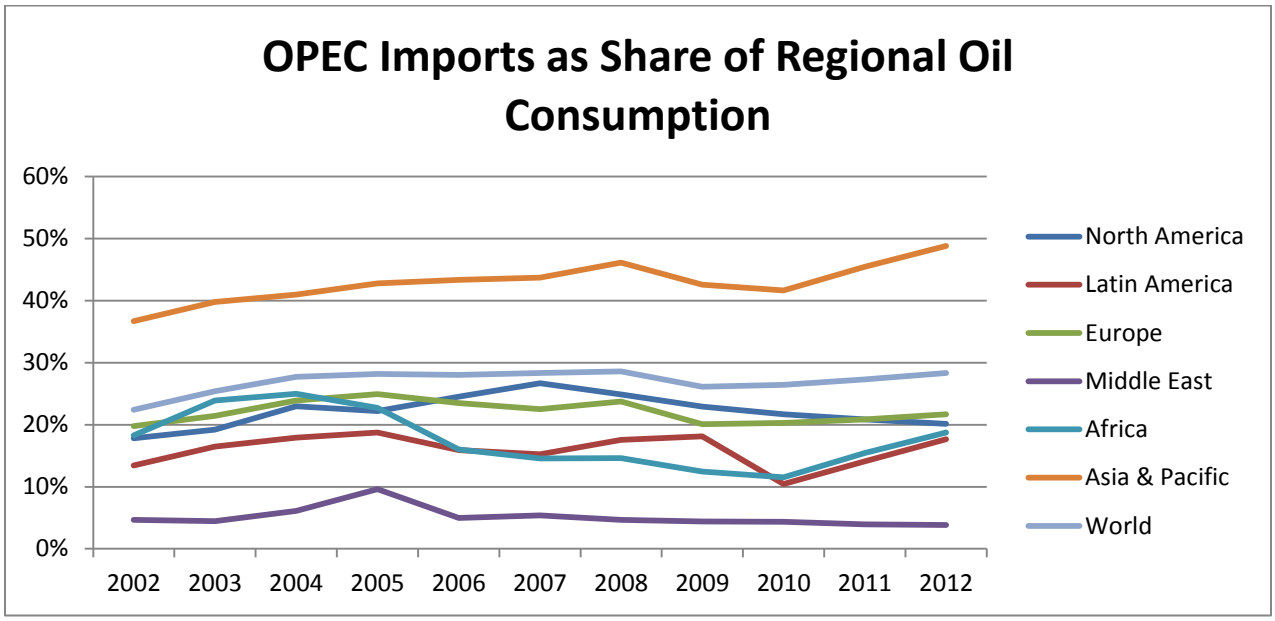

Figure 7: OPEC Imports as a Percentage of Regional Oil Consumption

Sources: Organization of the Petroleum Exporting Countries . *OPEC Annual Statistical Bulletin*. (2002, 2007 and 2013) and U.S. Energy Information Administration. "Table: Total Petroleum Consumption." *International Energy Statistics*. (2013)

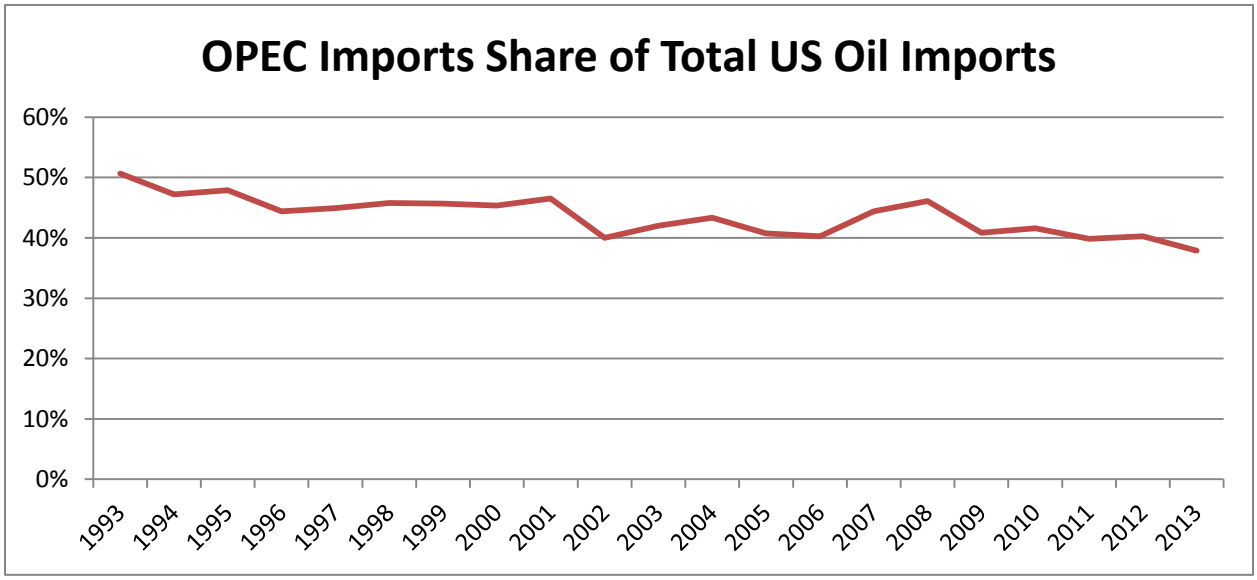

Figure 8: US Imported Oil from OPEC as a Percentage of Total US Oil Imports

Sources: U.S. Energy Information Administration. "Table: US Imports from OPEC Countries of Crude Oil and Petroleum Products." *Petroleum & Other Liquids.* (2013) and U.S. Energy Information Administration. "Table: US Imports of Crude Oil and Petroleum Products." *Petroleum & Other Liquids*. (2013)

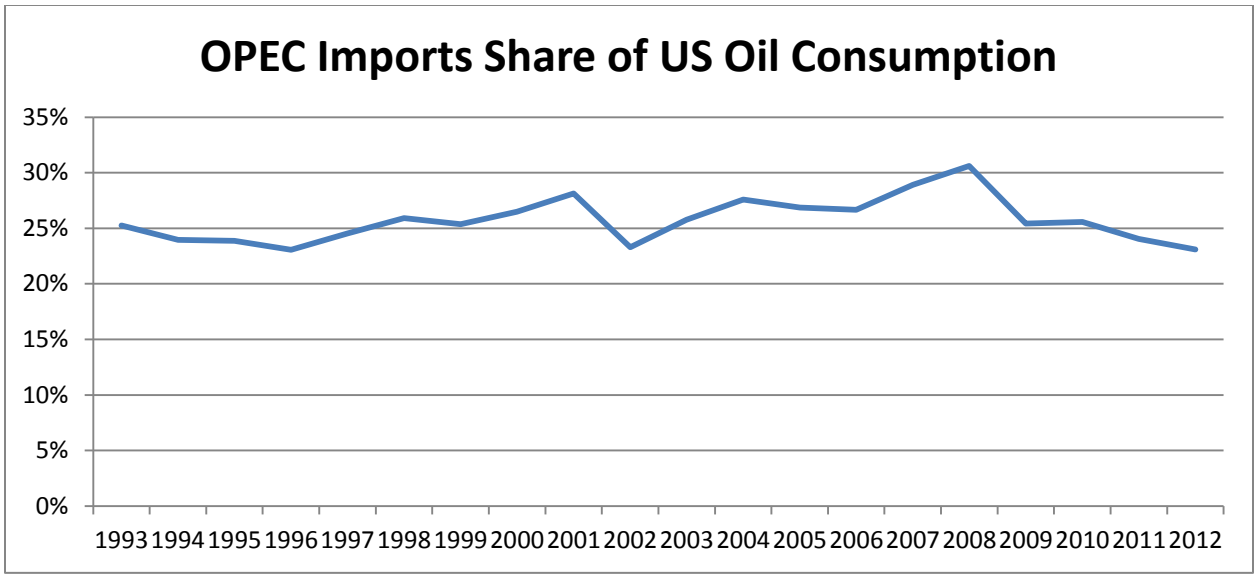

Figure 9: US Imported Oil from OPEC as a Percentage of Total US Oil Consumption

Sources: U.S. Energy Information Administration. "Table: US Imports from OPEC Countries of Crude Oil and Petroleum Products." *Petroleum & Other Liquids.* (2013) and U.S. Energy Information Administration. "Table: Total Petroleum Consumption." *International Energy Statistics*. (2013)

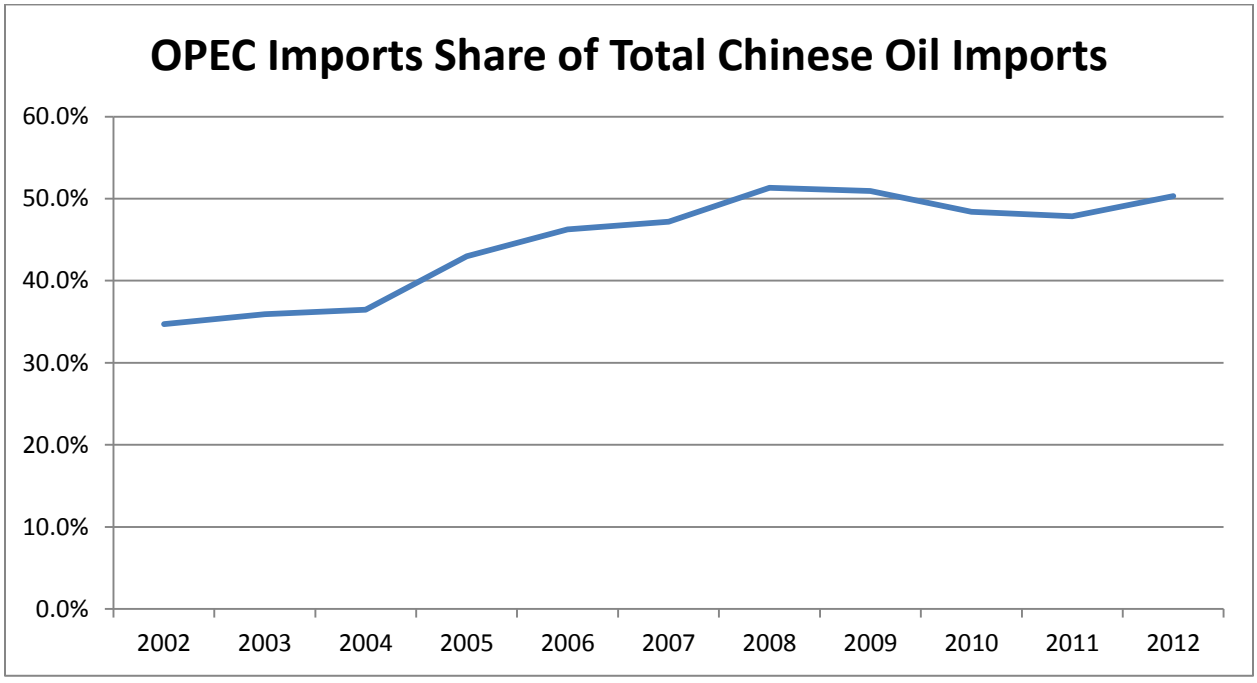

Figure 10: Chinese Imported Oil from OPEC as a Percentage of Total Chinese Oil Imports

Source: United Nations Publications Board. *United Nations Commodity Trade Statistics Database*. (2013)

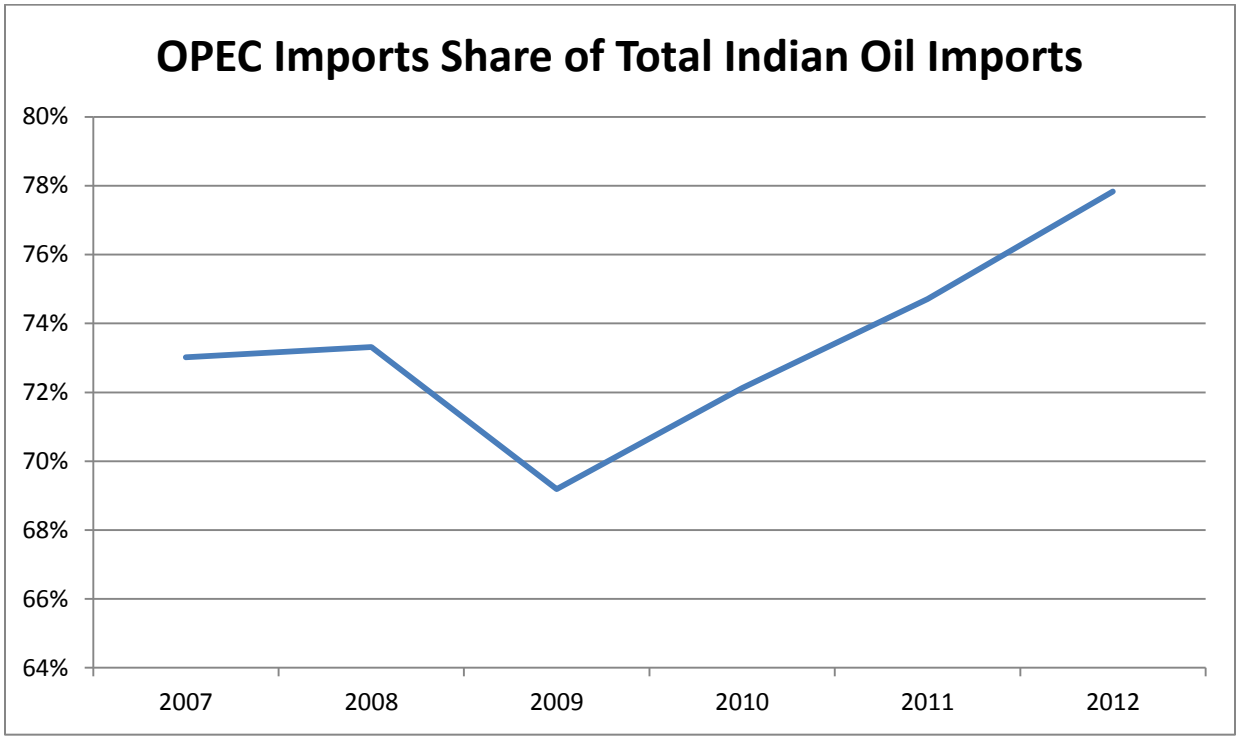

Figure 11: Indian Imported Oil from OPEC as a Percentage of Total Indian Oil Imports

Source: United Nations Publications Board. *United Nations Commodity Trade Statistics Database*. (2013)

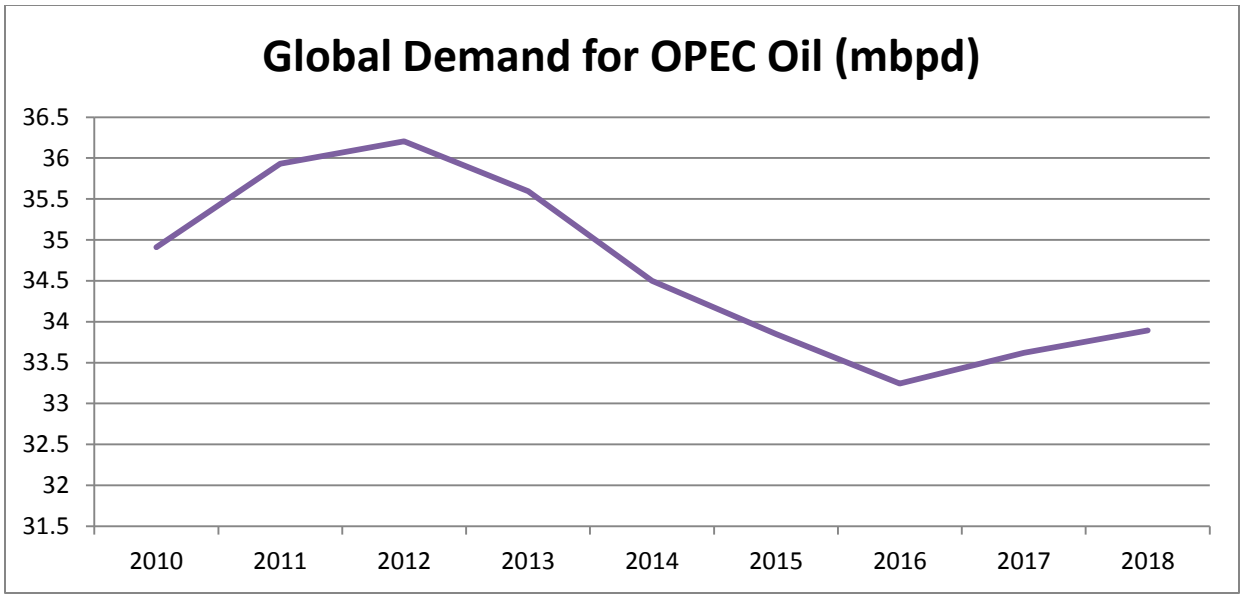

Figure 12: Global Demand for OPEC Oil

Sources: U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." ***Annual Energy Outlook 2013*****. (2013)**

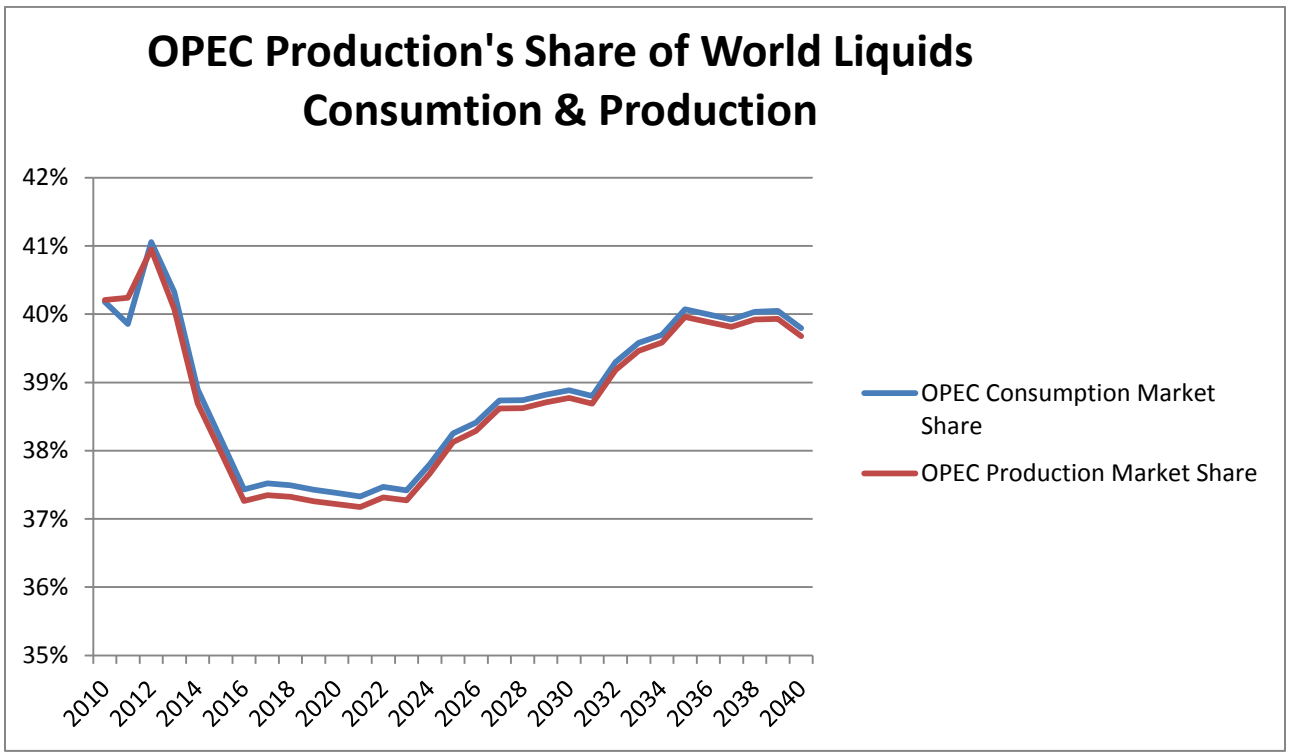

Figure 13: OPEC Liquids Production as a Percentage of Global Liquids Consumption and Production

Source: U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." *Annual Energy Outlook 2013*. (2013)

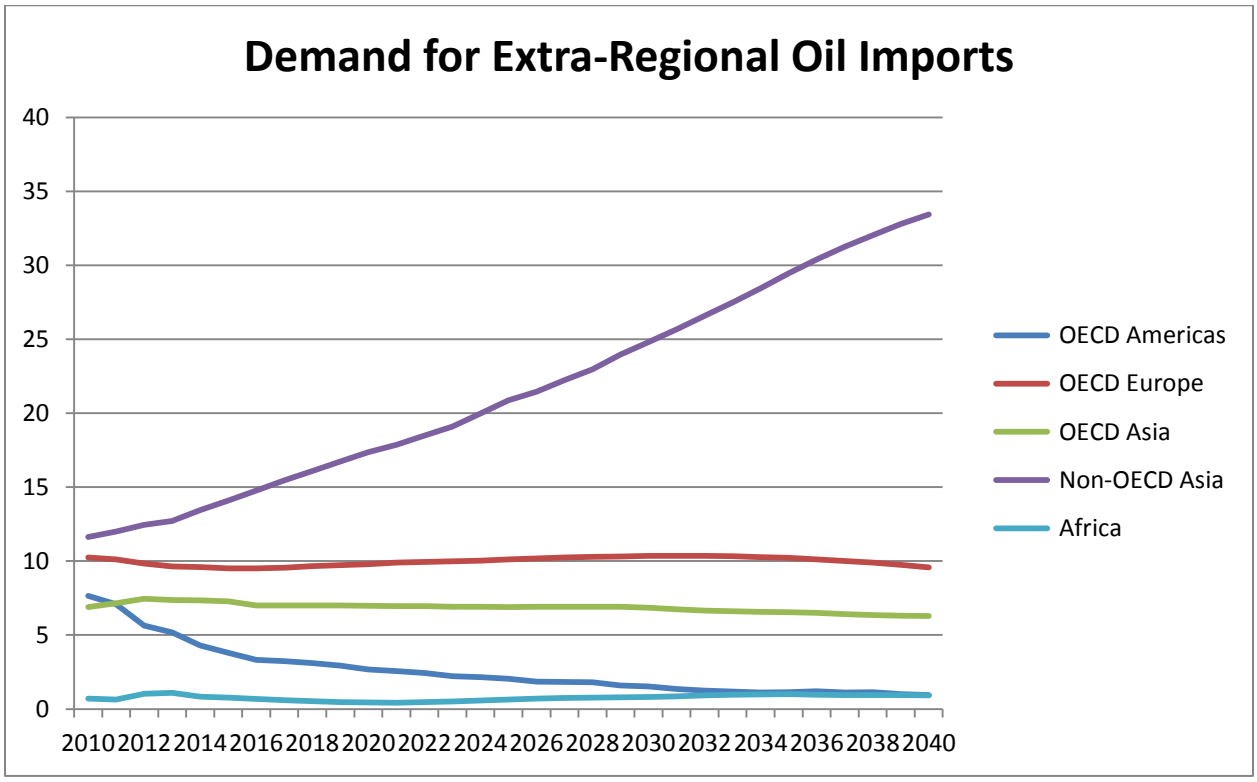

Figure 14: Regional Demand for Oil Imports from Outside of Respective Regions

Source: U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." *Annual Energy Outlook 2013*. (2013)

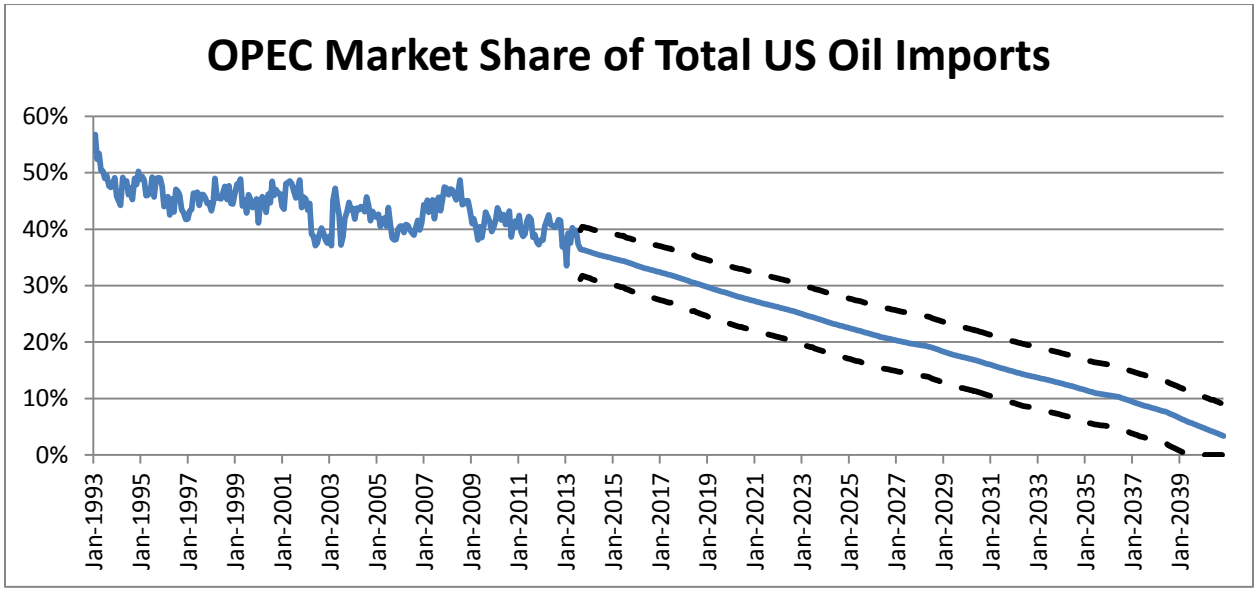

Figure 15: Forecasted OPEC Imports as a Percentage of Total US Oil Imports

Sources: U.S. Energy Information Administration. "Table: US Imports from OPEC Countries of Crude Oil and Petroleum Products." *Petroleum & Other Liquids.* (2013) and U.S. Energy Information Administration. "Table: US Imports of Crude Oil and Petroleum Products." *Petroleum & Other Liquids*. (2013)

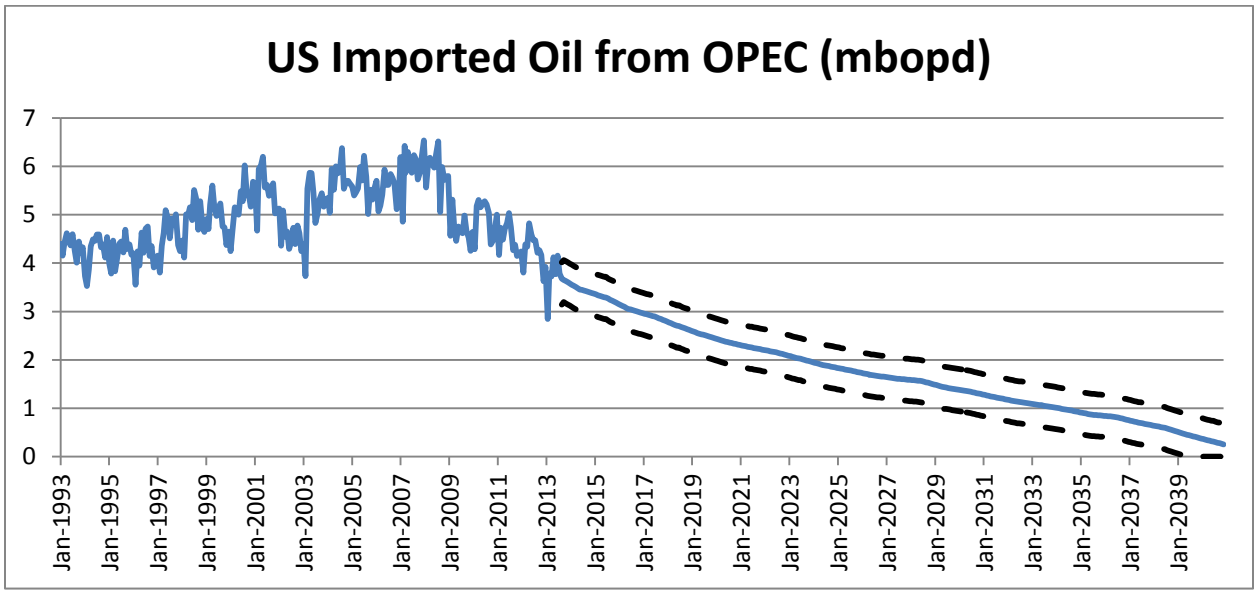

Figure 16: Forecasted of Volume of OPEC Oil Imports to the US

Sources: U.S. Energy Information Administration. "Table: US Imports from OPEC Countries of Crude Oil and Petroleum Products." *Petroleum & Other Liquids.* (2013) and U.S. Energy Information Administration. "Table: US Imports of Crude Oil and Petroleum Products." *Petroleum & Other Liquids*. (2013)

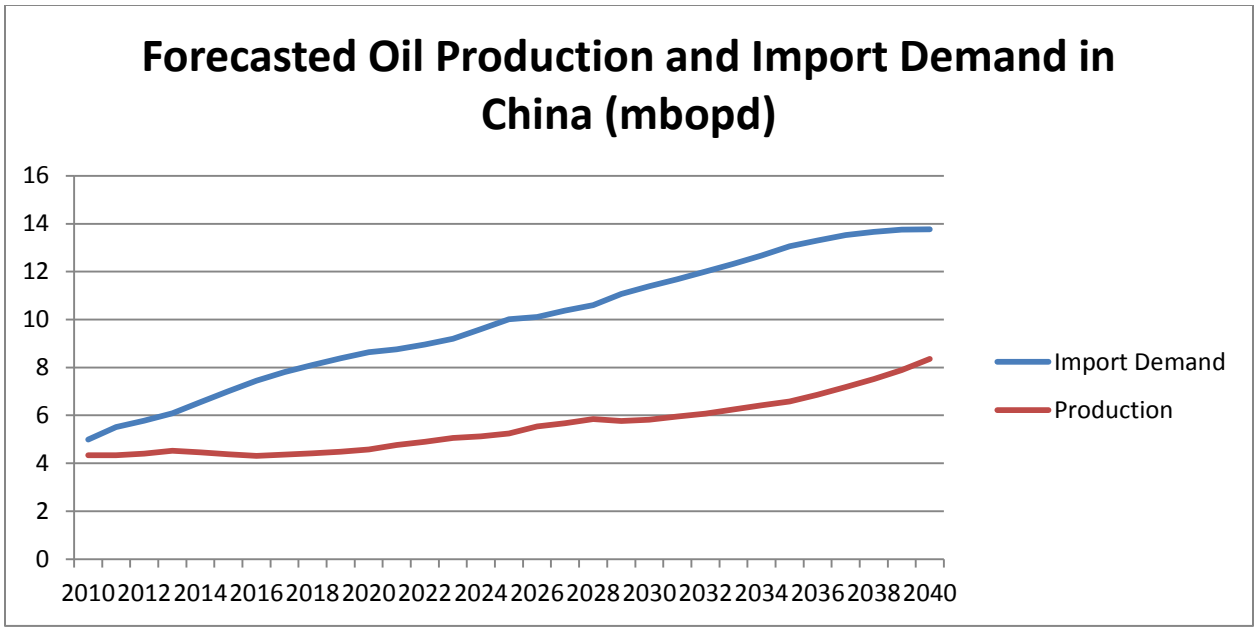

Figure 17: Forecasted Oil Production and Import Demand in China

Source: U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." ***Annual Energy Outlook 2013*****. (2013)**

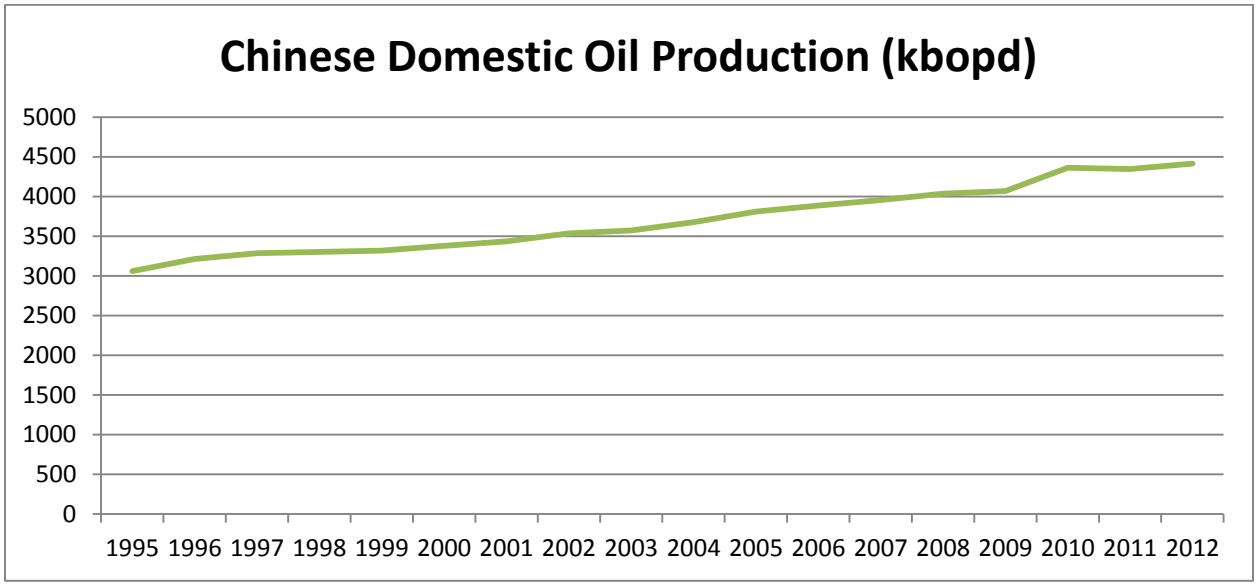

Figure 18: Historical Domestic Oil Production in China

Source: U.S. Energy Information Administration. "Table: Total Oil Supply." ***International Energy Statistics*****. (2013)**

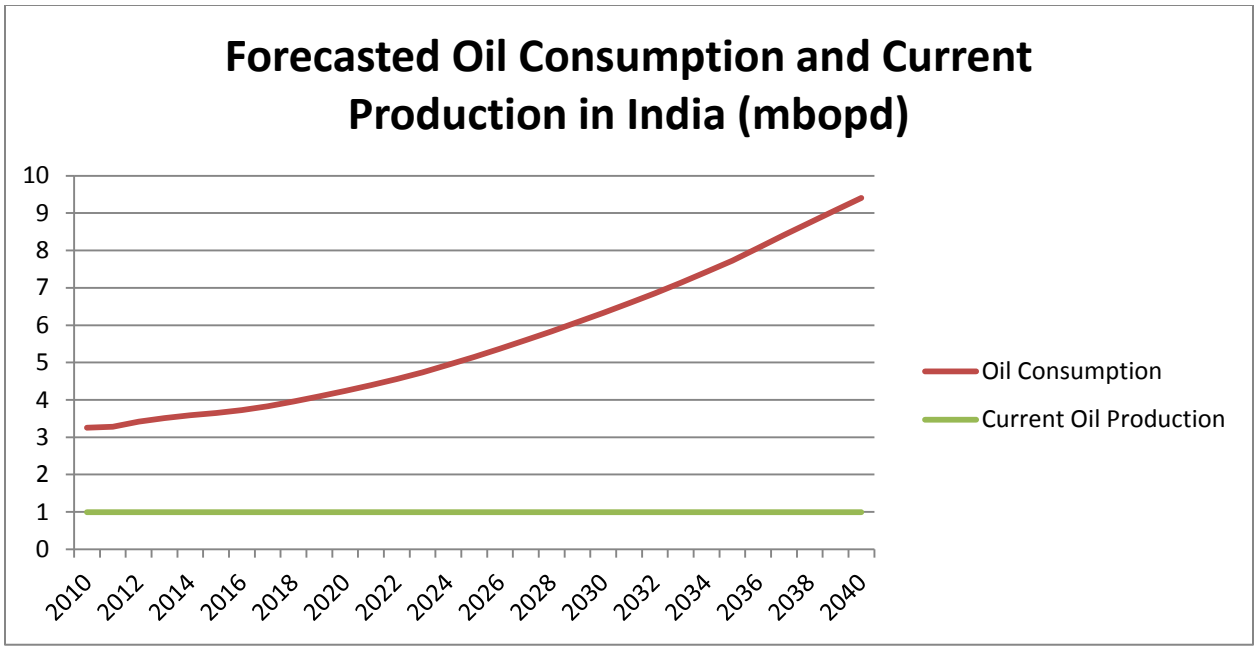

Figure 19: Forecasted Oil Consumption and Current Oil Production in India

Source: U.S. Energy Information Administration. "Table: International Liquids Supply and Disposition, High Oil Price." ***Annual Energy Outlook 2013*****. (2013)**

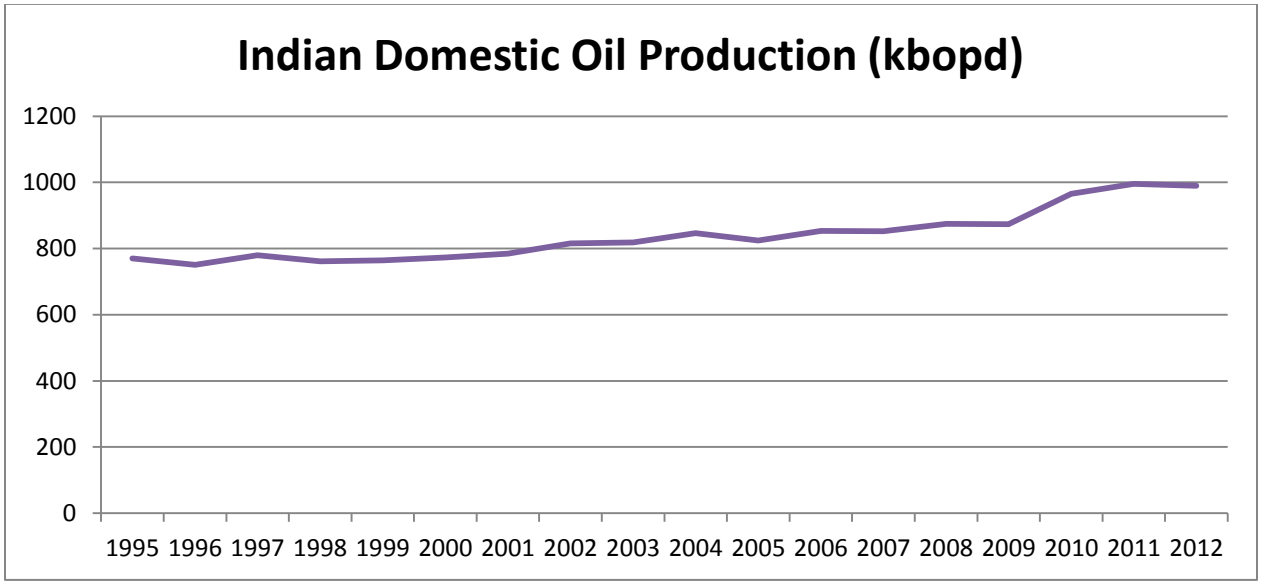

Figure 20: Domestic Oil Production in India

Source: U.S. Energy Information Administration. "Table: Total Oil Supply." ***International Energy Statistics*****. (2013)**

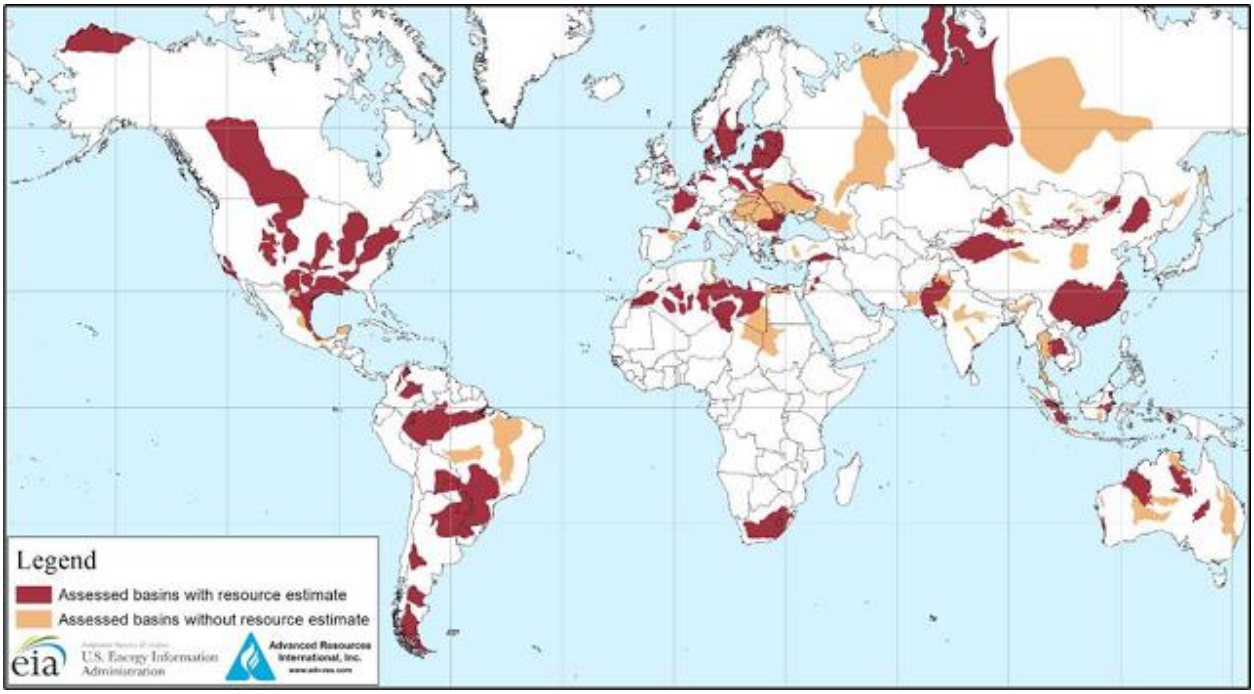

Figure 21: Location of Assessed Shale Reserves Globally

Source: U.S. Energy Information Administration. ***Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*****. (2013)**

Table 3. Granger Causality Tests

	To:		
From:	**OPEC**	**Non-OPEC**	**RAC**
OPEC	0.00	0.36	0.14
Non-OPEC	0.01	0.00	0.03
RAC	0.02	0.57	0.00

Notes: The null hypothesis is that there is no Granger causality. P-values are shown.

Figure 22: Granger Causality Tests of OPEC production, aggregate Non-OPEC production, and refiner acquisition cost of crude oil imports (RAC)

Source: Li (2010)

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