

# Global oil dependency and Security risk: “The scramble for oil Resource”

Dr. Charles Awoala Briggs

Southern University @ New Orleans, New Orleans, LA 70126. U.S.A.

**Abstract**— Exploration and production of crude oil is dependent on availability and access to reserves to enable a continued supply to satisfy the growing global demand for oil. Although oil is a depletable asset, it is a commodity that is irreplaceable with alternative sources such as natural gas and nuclear energy; therefore, there is the probability that in years to come people would live in a world without oil. Although many oil-producing nations have reserves, the Middle East seems to be more concentrated with oil reserves. The importance of oil has lead oil consuming nations to be concerned about the security of oil supplies from the major oil producing countries. The risk of oil supply has been a major security policy issue since the 1970's. Most of the Organization for Economic Co-operation and Development (OECD) economies' dependency on imported oil from the Middle East increased with the growth in political instability of the major oil exporting nations, OPEC's rising influence, the 1973-1974 Arab oil embargo (U.S. Department of State, 1976), and the nationalization of the upstream oil supply chain. Regrettably, all these could lead to, or give rise to erratic oil supply risk.

**Keyword**— Oil supply risk, oil Security, oil dependency, upstream oil supply chain risk.

## I. INTRODUCTION

Global demand for oil is increasing, but supplies of this key energy source are limited, so availability will be constrained, and its price will rise with serious implications for prosperity and stability worldwide, creating a worsening security challenge. The Saudi spare capacity has deteriorated over the past decade, by one-half, from 3-4 million barrels per day to 1-1.5 million barrels per day. The loss of spare capacity will have strong implications for both the functioning of the oil market and the energy security agenda (Fattouh, 2006). To make matters worse, some experts question reserve estimates provided by national oil companies in the gulf and elsewhere, as the numbers are not independently audited. Without a clear understanding of how much oil is available, the world may be up for more nasty surprises (Cohen, 2007). Globalization today is drawing the oil producing nations together and increasing their interdependence, and the fates and prosperities of these nations are closely tied to the global economy. This globalization and interdependence are also creating new challenges for the oil industry; indeed, the biggest challenge is to provide significantly more oil at a reasonable cost in both a safe and environmentally friendly manner. Currently,

the world's oil production and supply capabilities are reaching their peak while global oil production is barely one million barrels a day over global consumption. This means that the rising surge in demand from developing countries, especially China, will lead to global demand outstripping supply in the next two decades (Pocha, 2005:52). Recent rises in oil prices have spurred many new exploration activities, yet still, the oil industry faces the challenge of developing a comprehensive strategy to change the climate of oil investment, while building more tankers, pipelines, and refineries to adequately meet the rapidly growing global oil demand. Safety and security challenges in the oil supply chain are sometimes viewed as one physical security issue, but in essence there are emergency response, process control, physical and cyber security issues along the supply chain. Energy security conceptually means the “availability of energy at all times in various forms and in sufficient quantities and at affordable prices” (Umbach, 2003:141). In today's global economy, the importance of Africa's oil resources has indicated that the demand for energy is estimated to rise by more than 50 percent by the year 2030, of which 80 percent would still be met by fossil fuels (Global Energy Security Principles, 2006).

Indeed, the global economy operates based on a flawed premise surrounding the infinite and continued availability of natural resources and raw materials. However, it is a reality that the earth is a finite system with limited amounts of natural and raw materials that can be exploited and used towards capital accumulation. Consequently, the finite nature of the earth's resources is a potential catalyst for conflict and competition both between and within countries. As a direct result, the scarcity of the earth's resources has created an environment in which resource acquisition and subsequent security have taken center stage within many countries. The continued availability of affordable and uninterrupted supplies of crucial strategic resources has manifested into the securitization of resources and resource supplies (Rooyen and Solomon, 2007).

Like it or not, for as long as we continue to rely on petroleum as a major source of energy, our security and our economic wellbeing will be tied to social and political developments in these unpredictable and often unfriendly producers (Klare, 2004).

## **II. BACKGROUND OF THE STUDY**

Oil serves a wide diversity of purposes, including transportation, heating, electricity, and industrial applications, and it is an input into over 2,000 end products (International Labor Organization 2002). It is used as a raw material in many chemical products, such as pharmaceuticals, fertilizers, plastics, solvents, and pesticides. Overall, petroleum products derived from oil, such as motor gasoline, jet fuel, diesel fuel, and heating oil, supply nearly 40% of the energy consumed by households, businesses, and manufacturers worldwide (Grant, K., Ownby, D., and Peterson, S.R. 2006). Despite the western multinational corporations' (the seven sisters) powerful economic control of oil production, other producing countries have an objective to control the supply and to earn a greater share of the oil income. Approximately 90 countries produce oil, although a few major producers account for the bulk of world output. The Middle East remains the biggest player in oil. Saudi Arabia alone possesses 21.9% of the world's proved reserves (BBC News July, 2008).

Oil resources play a very important role in the economic growth of every producing country; however, the reserves are not equitably distributed around the globe. According to a BP Statistical Review Report, about 61% of the world's proven oil reserves are located in the Middle East

and Middle East countries who are producing about 30% of the total amount of the world oil production (BP, 2008 and Energy Information Administration (EIA), 2008).

The presence of oil has negative social and environmental impacts, from tanker accidents; further, routine activities such as seismic exploration and drilling have damaged the atmosphere and several ecosystems around the world. For example, crude oil spills from tanker ship accidents have damaged ecosystems in Alaska, the Galapagos Islands, Spain, and many other places around the globe. There are incidences of the search for oil, the likeliness of the oil industries to act in their best interests to optimize their profits, and the environmental destruction of oil leaks, that lead to protests and revolts by affected community groups. One unfortunate aspect of the oil industry is the heightened level of displaced peoples often associated with oil extraction in developing states. Once oil is discovered, it becomes the property of that country or, in the case of sales of concessions, the property of the company that first laid claim to it. In many cases the people who inhabited the region had no claim to the oil or right to the land. A gross example of this is the case of the Niger Delta Region where the Nigerian government has openly seized land and property from its own citizens for the sole benefit of companies such as Shell and British Petroleum (Salas, 2009).

Western countries are in search of new and secure oil farther away from the Gulf countries due to geopolitical risks, especially since 9/11 and the Iraq invasion. However, attention had shifted to West African countries, Central Asia, China and India, although the focus in China and India was more dispersed. In the global environment, the strategies used by the oil importing countries to secure oil reflect their perception of economic and political vulnerability. Overall, the countries that feel threatened by possible embargos, and supply disruptions tend to lean towards bilateral and regional alliances, while those who feel less threatened remain more market oriented in their strategies to secure oil for the economy (Noronha, 2005).

The 1973 and 1979-1980 oil shocks made "geopolitics of oil" the byword to describe the sources of uncertainty surrounding oil supplies and prices. Today, while geopolitics is not absent from the current oil shock, it is global economics that drive oil prices. In a world oil economy highly influenced by national oil companies, there are inevitable boundary issues, and in that sense, geopolitics still has a role to play (Munk, 2005). The stability of oil exporting nations is of paramount importance to the world oil

market. For example, the strike in Venezuela, the war in Iraq, and the disruptions of Angola and Nigeria oil were examples of what could happen if such incidents occur in other countries such as Saudi Arabia and Iran. Another OPEC oil embargo is very unlikely; however, if oil is ever used as a weapon to combat the United States or western foreign policy, or if sanctions were imposed on Iran, it will have devastating effects on the global economy.

Conflicts occur over control of oil, such as civil unrest or war that uses disruption of oil operations as a tactic, conflict with indigenous groups over oil development and even superpower geopolitics, e.g. control over Middle East oil reserves (O'Rourke & Connolly, 2003). Unfortunately, disagreement over control of oil revenue by ethnic groups has always destabilized countries and disrupted the flow of oil.

Research has shown that the price of oil accurately tracks geopolitical risk factors, with greater weights given to the politics of the Middle East. The greater the geopolitical risk at any time, the greater the price of oil and vice-versa (Shaunak, 2007). The issue of access to countries with oil resources is also mired in geopolitics. For both China and India, the Caspian Sea is a major attraction for its oil and gas resources. But the region is still difficult to access, given the geopolitics of the region and Russia's strategic interest to make it a part of its security system. The lack of a clear international legal regime on resource ownership centered around the issue of whether it is a sea or a lake, and the absence of institutions to ensure that oil development is smooth and instills confidence in international investors.

Moreover, even as the newly independent states of Azerbaijan, Kazakhstan, and Turkmenistan are eager to develop their resources and create international linkages, the region needs access routes to global markets for its energy resources. Since the existing transportation routes are mostly through Russia, attempts are being made to diversify these routes through other neighboring countries, both to increase geographical access to East and South Asia, and to reduce dependence on Russia. Until these issues – strategic, security, economic and legal – are resolved, the Caspian Sea energy resources will remain a potential source of great conflict as the scramble for resources increases. In the case of Venezuela on the other hand, China and India may benefit, as President Chavez sees oil as a 'geopolitical weapon' to contain the US. (Noronha, 2005).

### III. LITERATURE REVIEW

In order to develop a comprehensive model for oil dependency and security risk and the oil supply chain network, some leading studies in fields of oil supply risk, oil availability and security risk, and oil supply chain risk management, are reviewed for this study.

#### Oil Supply Risk

Risk and uncertainty are a widely discussed issue in supply chain management literature and are often used synonymously. However, they are distinct concepts. Risk is often identified to be the consequence of uncertainty (Lalwani, Disney, & Naim, 2006). One of the most pressing areas for companies in today's global business environment is the assessment and management of risk. Managing risk is cited as one of the primary objectives of firms operating internationally (Ghoshal, 1987). In a modern complex decision-making environment, to mitigate risk, an organization must recognize the extent, likelihood, and consequence of the risk to the organization. Miller (1992) adopts the term 'uncertainties' to refer to the unpredictable nature of the operating environment in which companies operate, and then categorizes these uncertainties according to their source. Iwan, Suhaiza, and Nyoman (2009) argue that although supply chain management has always had a strong emphasis on risk, the notion of supply chain risk management has gained an increasing popularity in recent years due to increasing supply chain complexity. However, Faisal, Banwet, and Shankar (2006b) and Tang (2006) believe that effective supply chain risk management (SCRM) is an imperative for companies. Srividhya and Raj (2007) suggest that global corporations therefore need to develop and follow an all-encompassing and holistic risk management model – one that looks at all the uncertainties and their degrees of influence on the various segments of the global supply chain.

For the oil industry, the upstream sector is characterized as a "high-risk" industry due to the sizeable investment level, geological uncertainties, and other risks related to fiscal and political uncertainties with host countries. Therefore, the risks encountered in the upstream sector need to be addressed to ensure commercial viability of an oil project (Al-Thani, 2008). Risk management involves identifying the supply chain risk events, assessing the probabilities and the severity of impacts, prioritizing the risk event, and developing actions for mitigating the risk. It also involves the course of actions to consider in reducing the

risks. According to (Iwan, Suhaiza, & Nyoman, 2009), risk management involves such options as transferring it to or sharing it with other parties, accepting it as it is, or avoiding the risk. Many studies exist in international literatures that identify specific risk in the oil supply chain. A proposed energy supply risk categorization falls into source dependence, facility dependence, transit dependence and structural risk, which includes natural disasters, political blackmail, terrorism, war, civil unrest, and etc (Weisser, 2005).

However, Stern (2002) categorizes risk in the energy supply to include import dependence, source dependence, transit dependence, facility dependence and security dependence. Fattouh (2007) categorizes risk in the energy supply to include war and civil conflicts, political instability, regime change, revolutions, successful terrorist attacks on oil facilities, export restriction, closure of trade routes, and sanctions. Mitchell (2002) stipulates that oil supply risk can be categorized according to the period: 1) Short term (12–18 months): disruptions of international supplies, 2) medium term (3–5 years): export cartel issues, medium term: political issues, 3) long term (10–15 years): resource shock, medium to long term: ‘Real climate policy’ shock.

Reports from the Department of Homeland Security (DHS), the U.S. Department of State, and the Federal Bureau of Investigation (FBI) have indicated that the petroleum industry may be a target of terrorism due to the inherent nature of the products used and its importance to the national infrastructure (American Petroleum Institute 2005). Attacks on oil installations have become the weapon of choice for the international terrorism, irrespective of the political system and social-financial boundary conditions of the society under attack (Steinhausler, Furthner, Heidegger, Ryndell, & Zaitseva, 2008).

Terrorist attacks, though not so often, can cause damages and disruption along the crude oil supply network. Specifically the petroleum industry may be a target for terrorism due to the following characteristics: 1) the physical and chemical properties of the products handled at petroleum sites, 2) the importance of petroleum to the national economy, 3) the importance of petroleum to national security, and 4) the symbolism of the industry as a cornerstone of capitalism and western culture (American Petroleum Institute, 2005). Regrettably, prominent terrorist leaders have consistently made it clear that the petroleum industry is one of their principal strategic targets. They have

for several years denounced the West’s “theft” of oil and resources from the Middle East and Africa; therefore, the strategy to attack oil interests is part of an overall “bleed-until-bankruptcy” plan against the West and nations that are cooperating with the West and its corporate sector. The goal is to cut supplies or reduce them through any means (Goslin, 2008). Many Arab leaders understand the dynamic of the world’s oil dependence. For example: in 1990, the late Yassir Arafat stipulated that: When the North Sea oil dries up in 1991, the United States will want to buy Arab petroleum. And when the American oil fields themselves run dry and oil consumption in the United States increases, the American need for the Arabs will grow greater and greater. (Mitchell G. Bard, 2006).

Terrorist attacks that have been carried out to date on oil infrastructure have caught oil producers unprepared. For example, al-Qaeda’s February 24, 2005, attack on the Aramco facility in Abqaiq and Saudi Arabia sent shock waves through the world’s financial markets. On the same day, the price of oil on international markets jumped nearly \$2.00 per barrel, despite the attack’s complete failure (Cohen, 2007). Most analysts agree that the February attack, an additional attempt on March 28, 2005, and a 9/11-style assault in April 2007, all of which were successfully averted, were merely trial runs in a much longer campaign designed to disrupt the global economy in general, and the oil industry in particular (Stratfor Global Intelligence, 2006).

Since global economic survival depends on a continuous reliable supply of petroleum products, it is therefore imperative to mitigate security threats in this industry worldwide. The identified upstream crude oil supply chain risks includes 1) exploration and production risk, 2) environmental and regulatory compliance risk, 3) transportation risk, 4) availability of resource risk, 5) geopolitical risk, and 6) reputational risk. Briggs., Tolliver., & Szmerekovsky (2012). & (Briggs, C. 2017)

## **OIL AVAILABILITY AND SECURITY RISK**

The oil industry is a combination of the global processes of exploration, extraction, refining, transportation, and marketing of petroleum products. Global demand for oil products is the fundamental driver of the oil industry; a relevant portion of the world economy and the growing worldwide welfare still relies on oil product consumption, both for industrial production and for transportation. The evolution of the Oil industry dates back thousands of years. Oil from its discovery was used in the Middle East in paints,



lighting, waterproofing of boats and baskets, and even in some cases medication. Whale oil was used as a source of domestic light, which led to an increase in demand for whales and subsequently an increase in the price of whale oil. As a result, commercial, industrial, and domestic users started seeking an alternative source, which later became widely known as “Black Gold” (Dimitrova & Lopez, 2005). Land oil wells were found below the seabed, which gave rise to exploration and the building of the first oil well in the open waters of the Gulf of Mexico.

In the 1920s land oil wells were found in Europe, and in the 1960s, exploration began in the North Sea, although without success until 1969 when a new field was discovered and explored west of Scotland in the Atlantic. Indeed, from 1948 to 1972, world oil consumption increased dramatically, hence this period was named “the golden age of oil”. In 1960, the Organization of Petroleum Exporting Countries (OPEC) was formed, to unify the petroleum policies of the major 12 oil producing and exporting countries and began to control the oil business that benefitted its members. In 1961 the Organization for Economic Cooperation and Development (OECD) was formed which helped member countries expand in free trade and cooperate in issues of international economic importance: for example, dealing with the OPEC oil cartel.

In recent years, access to and control over oil is increasingly as important as actual ownership. As a result private companies are exerting critical control over the industry (O'Rourke & Connolly, 2003). Oil producing countries frequently exhibit some sort of nationalistic attitude towards their countries' natural resource endowments, hence the national oil companies (NOCs) are presumed to be the custodians of their countries' natural resources. A national oil company (NOC) is an oil company fully, or in the majority, owned by a national government. National oil companies that operate as an extension of the government or a government agency, including Saudi Aramco (Saudi Arabia), Pemex (Mexico), and PDVSA (Venezuela), support their government's programs either financially or strategically. The international oil companies (IOCs), including ExxonMobil, Royal Dutch Shell, and BP, are owned by their shareholders with the objective of maximizing shareholder's value. In contrast, the owners or shareholders of the national oil companies are the governments. As a result, NOCs were intended at their creation to do more than simply produce oil or gas for a nation (Marcel, 2006; McPherson, 2003; Stevens, 2008a; Van der Linde, 2000).

Exploration and production of crude oil is dependent on availability and access to reserves to enable a continued supply to satisfy the growing global demand for oil. Although oil is a depletable asset, it is a commodity that is highly irreplaceable with alternative sources such as natural gas and nuclear energy; therefore, there is the probability that in years to come people would live in a world without oil. Although many other oil producing nations have reserves, the Middle East seems to be more concentrated with oil reserves. The importance of oil has led oil consuming nations to be concerned about the security of oil supplies from the major oil producing (OPEC) countries.

Hussain (2006) stipulate that under the right conditions, OPEC nations can meet the expected growth in the world oil demand by expanding its oil production if the oil industry will remain profitable, considering the fact that OPEC is not the only supplier of oil in the international market, and as a result, cannot guarantee stable price and availability of supplies to all consumers at all times. Further, Hussain (2006), also contends that to enable OPEC provide enough investments to increase capacity to meet the expected growth in oil demand it must be able to obtain reasonable oil prices in real terms, i.e, taking account of imported inflation and changes in the U.S dollar exchange rate; and a reduction of taxes in the major oil consuming countries that limits the growth in oil demand and thus reduces the income of oil producing countries.

This ultimately limits the producing country's ability to invest in their respective productive capabilities, such as exploration and development, and consequently they are unable to match significant increases in global oil demand. Given the global dependency on oil, an inadequate supply to meet the increasing global demand will be very devastating.

Cohen (2007) argues that the main problem of oil shortages today is not a lack of reserves in the ground, but a lack of access above ground. In the 1980's and early 1990's, several articles were written about ownership of oil resources. Thereafter, however, the industry received limited attention: oil prices were low, supply seemed secure, and the fall of communism opened new opportunities for the international oil majors (Wolf, 2008).

The risk of oil supply has been a major security policy issue since in the 1970's, as most of the OECD economies' dependency on imported oil from the Middle East increased with the growth in political instability of the major oil exporting nations, OPEC's rising influence, the

1973-1974 Arab oil embargo (U.S. Department of State, 1976), and the nationalization of the upstream oil supply chain. Regrettably, all these could lead to, or give rise to erratic oil supply risk. The threat of security of oil supply can be analyzed either in terms of demand for the producing country or supply for the consuming country. For the producing country oil security means security of demand, while for the consuming country it means security of supply (Opoku, 2009). Blum and Legey (2012) also contend that oil security is a key-element of economic development, therefore continuity, adequacy and affordability of energy supply must be guaranteed. Khatib (2000) also defines oil security as the continuous availability of oil in different forms, in sufficient quantities and at affordable price levels. Yergin (2006) defines energy security as the “availability of sufficient supplies at affordable prices.” Kalicki and Goldwin (2005) similarly define energy security in terms of “provision of affordable, reliable, diverse and ample supplies of oil and gas and their future equivalents and adequate infrastructure to deliver these supplies to market.”

Apparently, oil security issues are not a new concern; they have since become a matter of both national and international concern (Opoku, 2009). For example, oil producing nations, such as OPEC, also need security of demand from their oil, since the economic survival of such nations depends on revenues from oil exports in foreign currencies that are used in reverse to import goods and

services required for development. Therefore, any unexpected reduction in the demand for oil exports and hence oil revenue, will have economic and political impact on these countries. Regrettably, under such conditions the world could face a shortage in oil supplies, which would have negative effects on the global economy (Hussain, 2006). According to documented literature (Karl, 1997; Gary & Karl, 2003; Moody-Stuart, 2003; Christian, 2003; Kleveman, 2003; Stevens, 2003; Katz et al. 2004; Shaxson, 2005), oil can have increasingly negative impacts on low-income producing countries. These negative effects include low and sometimes negative economic growth for the country, poor provision of basic public services, weak governance, widespread poverty and insecurity (Keith, 2005). Ross (2001) confirms that these poor countries that are dependent on oil revenue often experience slower economic growth, high levels of corruption, higher military expenditure, and incredibly worse performance on child malnutrition reduction as well as adult illiteracy and are more vulnerable to economic shock. Poor nations that are dependent on oil sales for key revenues are often adversely affected by the ownership of the resource (Karl, 1997).

According to Energy Information Administration (EIA) report in 2008 depicted in figure 1, global oil consumption grew by 1.1% in 2007 and it was expected to increase in the following years.

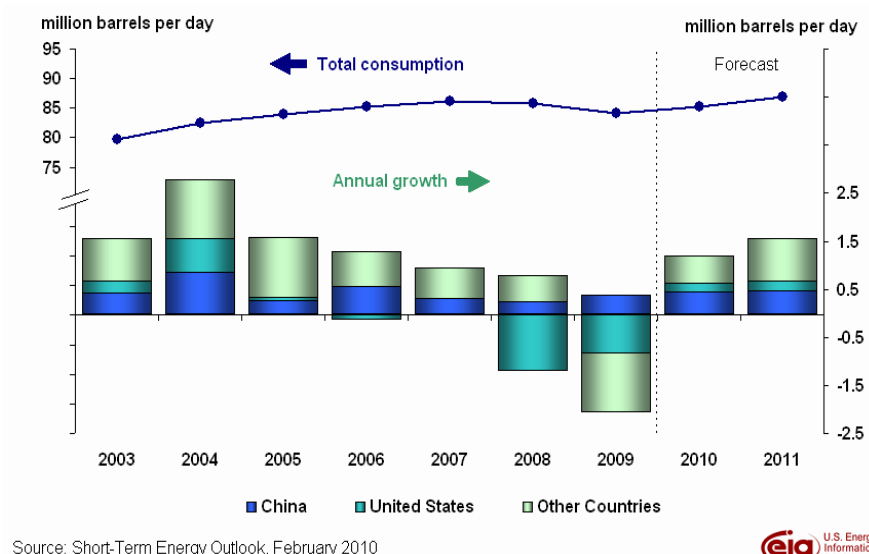


Fig.1: Global Crude Oil and Liquid Fuel Consumption.

However, Energy Information Administration (EIA) revised its projections slightly upward for global oil consumption growth as the Asian-led recovery continues. China's consumption in December 2009, increased by 0.9 million barrels per day, or 12%, above year-earlier levels, as China's economic stimulus package continued to help push up both oil usage and economic growth. Due to the increased liquid fuel consumption by China, Energy Information Administration (EIA) revised its prediction for global liquid fuels consumption to grow by 1.2 million barrels per day in 2010 and 1.6 million barrels per day in 2011 after showing annual declines in 2008 and 2009 (Energy Information Administration (EIA), 2010).

## ECONOMIC FREEDOM AND OIL DEPENDENCY

Many oil fields around the world are headed for depletion. National statistics are unreliable at best, or classified at worst, and national oil companies control up to 80 percent of oil and natural gas reserves. The main problem of oil shortages today is not lack of reserves in the ground, but lack of access above ground. (Ariel Cohen 2007). Figure 2 below shows countries by their dependence on exports of fuel commodities, which include natural gas and coal, as well as oil and oil products. Saudi Arabia is ranked 11th. Countries where fuel accounts for more than 90% of total exports include Algeria, Azerbaijan, Brunei Darussalam, Iraq, Kuwait, Libya, Sudan and Venezuela. For an idea of which economies rely most heavily on oil, this chart using 2012 World Bank data shows oil revenue as a share of GDP. Saudi Arabia comes third, after Kuwait and Libya, with roughly 45% GDP depending on oil. (World Economic Forum 2016).

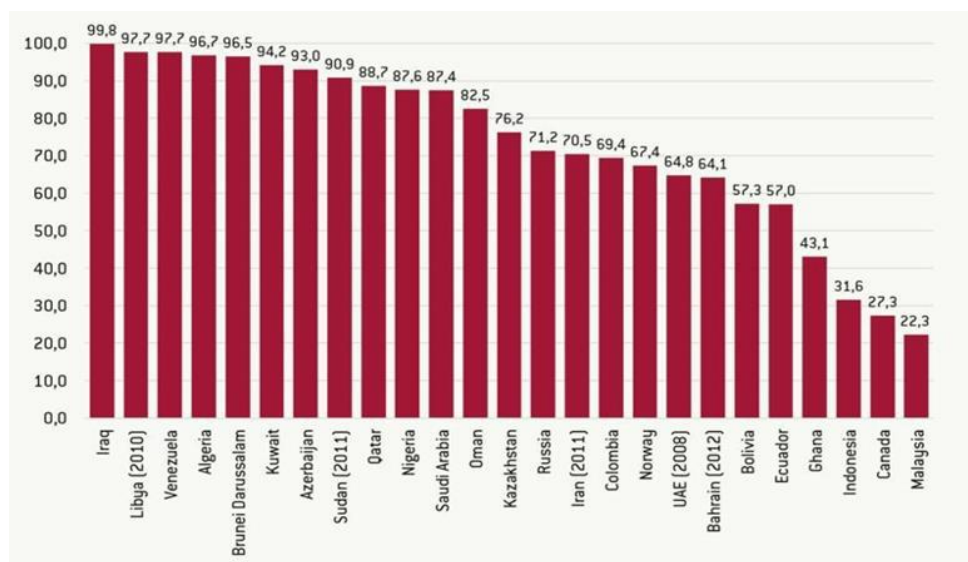


Fig.2: Fuel exports as percentage of merchandise exports, 2013 unless otherwise indicated

## World Bank data showing 2012 world oil revenue as share of GDP

Also, according to the U.S. Energy Information Administration (EIA 2010), U.S. liquid fuels consumption

depicted in figure 3, United States Crude Oil and Liquid Fuel Consumption, declined by 820,000 barrels per day (4.2 %) to 18.7 million barrels per day in 2009, the second consecutive annual decline.

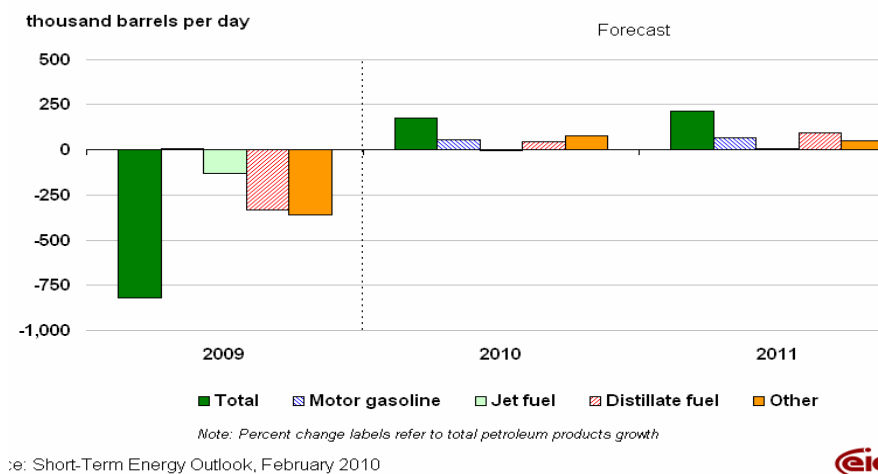


Fig.3: United States Crude Oil and Liquid Fuel Consumption.

Despite the cold weather that gripped much of the nation in late December 2009 and early January 2010, total U.S. liquid fuels consumption in those two months still fell below the levels seen in the same months a year earlier. Nevertheless, EIA projects that total petroleum products consumption will rise by 180,000 barrels per day in 2010 because of the economic recovery that began in late 2009.

Among the major international oil companies, ExxonMobil ranked 14<sup>th</sup>, BP, 17<sup>th</sup>, Chevron, 19<sup>th</sup>, ConocoPhillips, 23<sup>rd</sup>, and Shell, 25<sup>th</sup> in 2006. These five firms only hold 3.8% of the world liquid reserves, which are in the United States and Canada. However, the top ten companies listed in Table 1 hold 80.6% of the total world liquid reserves (Robert Pirog 2007).

Table 1. World Liquid Petroleum Reserves Holdings (Millions of Barrels)

Rank 2006	Company	Reserves	Rank 2000	Company	Reserves
1	Saudi Aramco	264,200	1	Saudi Aramco	259,200
2	NIOC	137,500	2	INOC	112,500
3	INOC	115,000	3	KPC	96,500
4	KPC	101,500	4	PDV	87,993
5	PDV	79,700	5	Pemex	76,852
6	Adnoc	56,920	6	Adnoc	50,710
7	Libya NOC	33,235	7	Pemex	28,400
8	NNPC	21,540	8	Lybia NOC	23,600
9	Lukoil	16,114	9	NNPC	13,500
10	QP	15,200	10	Lukoil	11,432

Source: Energy Intelligence Research, 2003.

Organization of Petroleum Exporting Countries (OPEC) members (Algeria, Indonesia, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela)

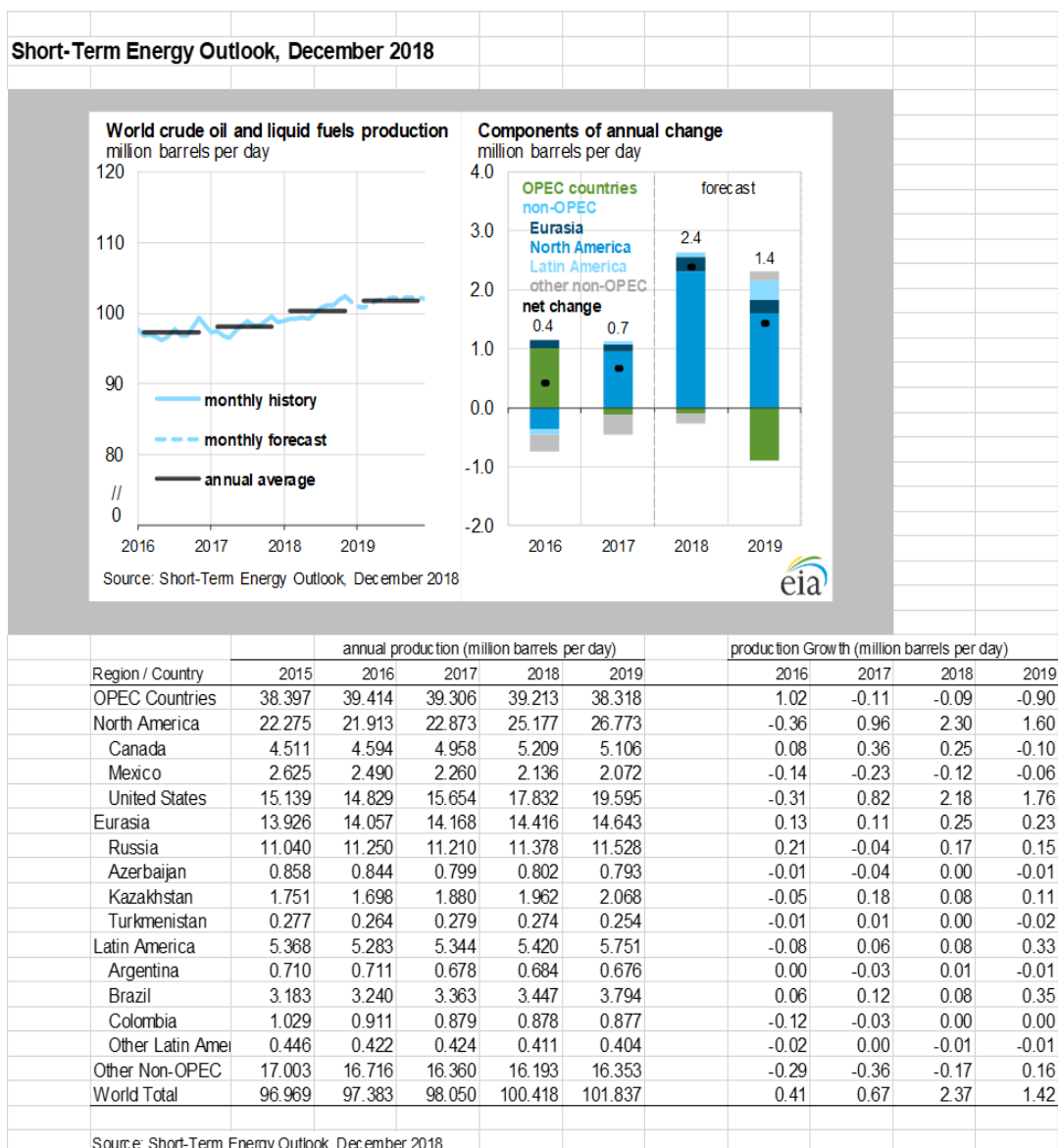
account for roughly 76% of the world's proven oil reserves and 40% of world production.



OPEC countries and national oil companies already hold the majority of proven (published) oil reserves, and the percentage of reserves they hold is increasing. Evidently, this concentration further establishes their future importance as major players in the world oil market and could potentially increase market tension and upward pressure on prices as world oil demand rises. This increased oil demand and unequal access to reserves has led to situations where International Oil Companies (IOCs) struggle for access to hydrocarbon reserves, controlled by National Oil Companies (NOCs) (Ruud & Jon, 2008). In the '90s, highly volatile oil

prices lead to a wave of consolidations in the oil market, which brought about structural shifts in the oil industry that have continued until the present day. During this period, a top echelon of four 'Super Majors' that was created (ExxonMobil, Royal Dutch/Shell, BP-Amoco, and Total FinaElf) have preponderance in the downstream, with 32% of global product sales and 19% refining capacity. This counterbalances to a large extent the dominant upstream positions of the four large state oil companies, Saudi Aramco, Petroleos de Venezuela, Iran's NIOC, and Mexico's Pemex. (O'Rourke & Connolly, 2003).

Table 2.



Brent crude oil spot prices averaged \$65 per barrel in November, indicating a decline of \$16/b from October, presenting the largest monthly average price decline since December 2014. EIA expects Brent spot prices will average \$61 in 2019 and that West Texas Intermediate (WTI) crude oil prices will average about \$7/b lower than Brent prices in the year 2020. NYMEX WTI futures and options contract values for March 2019 delivery that traded during the five-day period ending December 6, 2018, suggest a range of \$36/b to \$77/b encompasses the market expectation for March WTI prices at the 95% confidence level. EIA estimates that U.S. crude oil production averaged 11.5 million barrels per day in November, showing an increase of 150,000 b/d from October. EIA expects that U.S. crude oil production will average 10.9 million b/d in 2018, up from 9.4 million b/d in 2017, and will average 12.1 million b/d in 2019.

EIA forecasts total global liquid fuels inventories will increase by about 0.3 million b/d in 2018 and by 0.2 million b/d in 2019. Global liquid fuels production is forecast to increase by 1.4 million b/d in 2019. Oil production is expected to grow in the United States to be partially offset by declining production elsewhere, notably in the Organization of the Petroleum Exporting Countries (OPEC), where EIA forecasts that liquid fuels production will decline by 0.9 million b/d in 2019. EIA expects global liquid fuels consumption to increase by 1.5 million b/d in 2019, with growth largely coming from China, the United States, and India. United States Energy Information Administration (EIA 2018).

#### IV. RESEARCH METHODOLOGY AND PROBLEM DESCRIPTION

According to Blum and Legey (2012) energy security is not a new concept, however it requires new approach that covers supply and demand security. For several years different quantitative methods have been adopted to enhance rational decision making that involves multiple criteria, such as outranking method, judgmental modeling, weighted sum model, weighted product model, fuzzy sets, and AHP. In order to safeguard oil supply and demand security the AHP is considered as one well-known and most-used decision making models in situations where the decision criteria are based on multiple attributes. To the best of my knowledge there is no study to fill this gap it is therefore well

suited for eliciting and modeling the risk management preferences in the upstream crude oil supply chain.

#### Analytic Hierarchy Process

The analytic hierarchy process (AHP) has found widespread application in decision-making problems involving multiple criteria in systems of many levels (Liu & Hai 2005). Tam and Tummala (2001) also identify its usefulness when several decision makers with different conflicting objectives are involved. The analytical hierarchy process (AHP) provides a framework to cope with multiple criteria situations involving intuitive, rational, quantitative and qualitative, aspects (Alberto, 2000). Hierarchical representation of a system can be used to describe how changes in priorities at upper levels affect the priority of criteria in lower levels (Chan, 2003). It organizes the basic rationality by breaking down a problem into its smaller constituent part and then guides the decision maker through a series of pairwise comparison judgments to express relative strength or intensity of impact of the elements of the hierarchy (Saaty & Kearns, 1985). The AHP methodology is a flexible tool that can be applied to any hierarchy of performance measure (Rangone, 1996).

In this paper, the decision relates to the choice of one of the alternatives. The three components identified in the problem solving are 1) system decomposition, 2) comparative assessment, and 3) synthesis of priorities. System decomposing refers to the formation of the hierarchical structure with the basic objective that is with its goal, criteria and objectives, and alternatives. The mathematical model is the second component of the process where the priorities (weights) of the elements are placed at the same level of the hierarchical structure and calculated. The mathematical model is the basis for generating the ranking scale. The third component of the model means that the generated local priorities of the criteria and alternatives are synthesized into the total criteria alternative priorities.

The application of this method begins with the necessary definition of the hierarchy model and its elements with the goal at the top, criteria as sublevels in the middle and, finally, alternatives at the bottom. The next step is to generate a mathematical model. This model is based on mutual pairwise comparison, i.e., at each level of a hierarchy structure its elements are subjected to pairwise comparison.

On the basis of the mathematical model, and from the assessment of the relative importance of the elements of the corresponding level in the hierarchy structure, local

priorities, that is, weights of criteria as well as alternatives, are derived, and then synthesized in the total alternative priorities. In the end, the ranking list of the ranking values of the alternatives is obtained, so that the sensitivity analysis can be conducted.

The AHP has been a helpful methodology used in solving decision problems in studies such as supplier selection, forecasting, risk opportunities modeling, plan and product design, etc. (Siddharth, Subhash, & Deshmukh, 2007), as well as universally used in solving multi-attribute decision-making problems (Saaty, 1980). Dey (2001) described AHP as an effective tool for project selection. Dey, Tabucanon, Ogulana, and Gupta (2001) used AHP for cross country petroleum pipeline selection. Dey (2004b) used AHP in a decision support system for inspection and maintenance, a case study of oil pipelines. Nataraj (2005) used AHP as a decision-support system in the petroleum pipeline industry. Mustafa and Ryan (1990) used AHP for bid evaluation.

Despite the positive attributes, popularity, and simplified concepts of AHP that is widely reported in the literature, it is continuously being criticized for its inability to adequately handle the inherent uncertainty and impression associated with the mapping of the decision maker's perception to exact numbers. In the traditional formulation of the AHP, human judgments are represented as exact numbers. However, in many practical cases the human preference model is uncertain and decision makers might be reluctant or unable to assign exact numerical values to the comparison judgments (Felix & Niraj, 2005).

Although Belton and Gear (1985) and Dyer and Wendel (1985) criticize the AHP saying it lacks theoretical basis, Harker and Vargas (1987) and Perez (1995) counter the criticisms and contend that the AHP in fact, is based on a firm theoretical foundation.

### **AHP Application in Crude Oil Supply Chain Risk Management**

Risk assessment is most powerful when historical data or subjective expert opinions are available; however, in a situation of uncertainty, potential outcomes cannot be described in terms of objectively known probability distributions, nor be estimated by subjective probabilities (Haimes, 1998). The application of AHP to the upstream crude oil supply chain risk assessment decision problem entails three broad phases:

1). Structuring the complex decision problem as a hierarchy, displaying the ultimate objective or the overall

goal of risk management, the various risk factors and the alternative criteria of the decision maker. This hierarchical structure enables the decision-maker in structuring the complex system into manageable sub-system.

2). The prioritization process accomplished by assigning numbers from a scale developed by Saaty to represent the importance of the criteria. A matrix with pairwise comparisons with these attributes provides the means for calculation. The decision maker evaluates each criterion against all others and can express a preference between each pair as equal, moderate, strong, very strong, and extremely preferable (important). These judgments can be translated into numerical values on a scale of 1 to 9, with 1 being equal importance and 9 being very strongly important (Saaty, 2000). The decision maker evaluates each criterion against all others, and value of relative importance is assigned to more important criteria and the reciprocal to the lesser important. Elements at each level of the hierarchy are compared with each other in pairs, with their respective "parents" at the next higher level. With the hierarchy used here, matrices of judgments are formed.

3) After assigning all the relative comparisons, the principal eigenvector of the effects table is calculated for each criterion, which is normalized across all the criteria to equal 1 (Levy & Gopalakrishnan, 2009). With regard to the recommended steps by Saaty (2006), the hierarchy structure to model the upstream crude oil supply chain risk is shown in figure 4.

This section of the study is devoted to the categorization of risk that is taken into consideration in the risk assessment of the upstream crude oil supply chain. Since global economic survival depends on a continuous reliable supply of petroleum products, it is therefore imperative to mitigate the supply chain risks in this industry worldwide. The hierarchy structure to model the upstream oil industry supply chain risk, as shown in figure 4 identifies some upstream crude oil supply chain risks: (1) exploration and production risk, (2) environmental and regulatory compliance risk, (3) transportation risk, (4) **availability of oil resource risk**, (5) geopolitical risk, and (6) reputational risk. However, the alternative options proposed to manage the upstream crude oil supply chain risk as specified are: 1) Risk Acceptance. 2) Terminate or Forgo Activity. 3) Transfer or Share Risk. Briggs., Tolliver., & Szmerekovsky (2012).

It is therefore important to provide a methodology for identifying, analyzing, evaluating, and selecting a risk

treatment (mitigation) to manage these risks. Multi-Criteria Analysis Method and the Analytic Hierarchy Process was used to evaluate and prioritize these risks, as they are suitable

methodologies to solve decision-making problems, while focusing on the upstream crude oil supply chain. (Briggs, 2017).

## RISK ASSESSMENT AND PRIORITIZATION

### Model Description

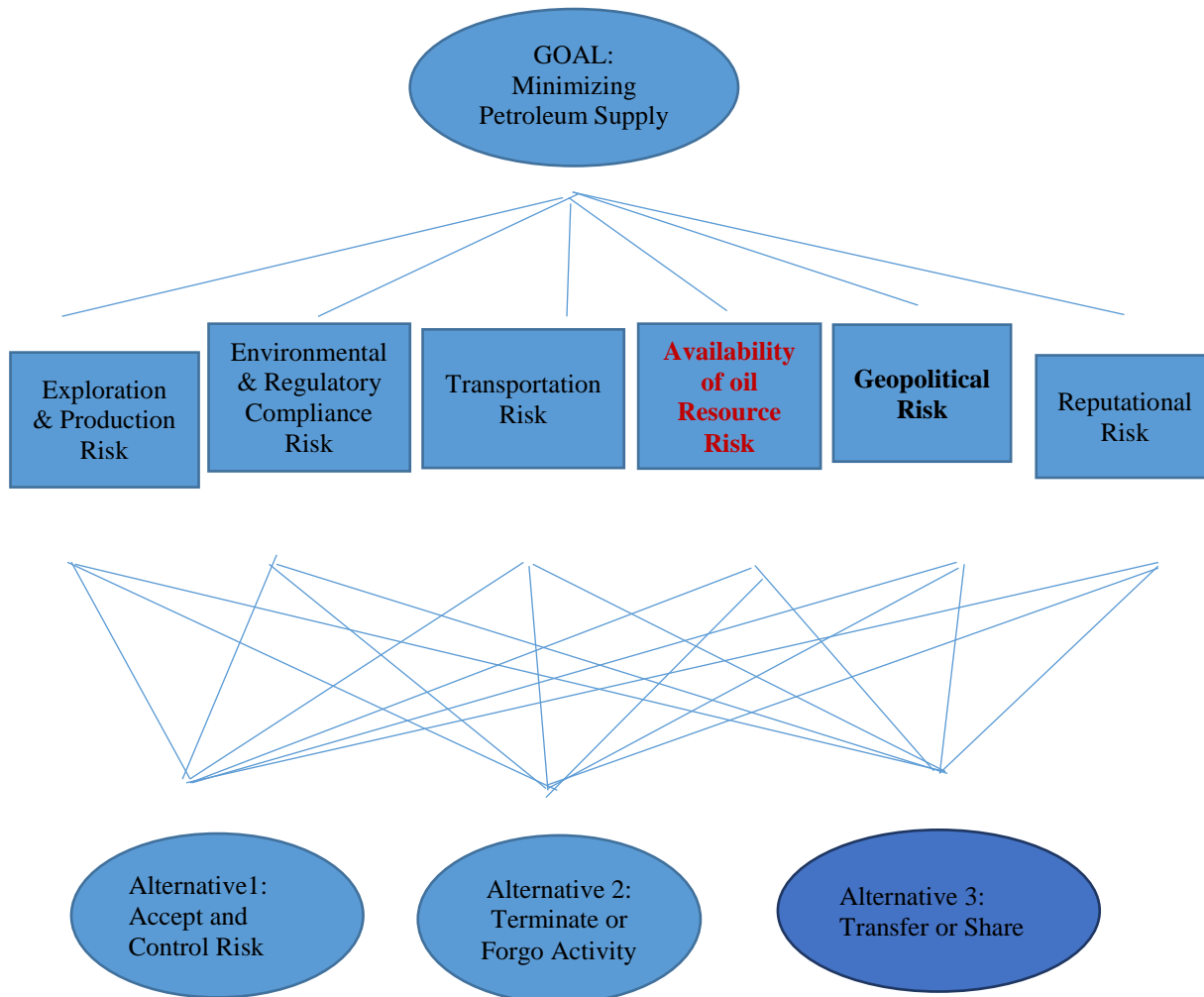


Fig.4: Oil Industry Risk Management Model

### The Hierarchy Structure of the Petroleum Industry Supply Chain Risk.

Adopted from: Briggs., Tolliver., & Szmerekovsky (2012). *Managing and Mitigating the Upstream Petroleum Industry Supply Chain Risk. Leveraging Analytic Hierarchy Process*

### Procedure

AHP application to the upstream petroleum supply chain risk entails three broad phases:

1). Structuring the complex decision problem as a hierarchy, displaying the ultimate objective or the overall

goal of risk management, the various risk factors and the alternative criteria of the decision maker. The structure of the hierarchy is organized by placing the objective at the first level, criteria second level, and decision alternatives at the third level as shown in figure 4. The identified decision criteria (risks) are: exploration and production, environmental and regulatory compliance, transportation, **availability of oil resource**, geopolitical and reputational risks. The alternative or preferred options of managing the risk specified at level three are: accept and control the risk, terminate and forgo activity, transfer or share risk.

The prioritization process is accomplished by assigning number from a scale developed by Saaty to represent the importance of the criteria. A matrix with pairwise comparisons with these attributes provides the means for calculation. The decision-maker evaluates each criterion against all others and expresses a preference between each pair as equal, moderate, strong, very strong, and extremely preferable (important). These judgments are translated into numerical values on a Saaty's scale of 1 to 9. shown in Table 3, with 1 being equal importance and 9 being very strongly important (Saaty, 2000).

Table.3: Saaty's 1-9 Scale of Relative Importance for Pair-Wise comparison (Saaty, 2006)

Identity of Importance	Definition	Explanation
1	The two objectives are equally important	Two activities contribute equally to the objective
3	One objective is moderately more important than the other	Experience and judgment slightly favor one activity over another
5	One objective is strongly more important than the other objective	Experience and judgment strongly favor one activity over another
7	One objective is very strongly more important than the other objective	An activity strongly favor one over another; its dominance demonstrated in practice
9	One objective is absolutely more important than the objective	Importance of one over another affirmed on the highest possible order
2,4,6,8	Intermediate Values	Used when compromise between the priorities are needed

### Solution Representation

In the upstream petroleum industry supply chain risk analysis, the AHP is a useful technique to accommodate the multiple dimensions and conditions that constitute supply chain risk.

1. Establishing the pairwise comparison matrix A is as follows: Let  $C_1, C_2, \dots, C_n$  represent the

set of elements, and  $a_{ij}$  represents the quantified judgment on a pair of elements  $C_i$  and  $C_j$ . Here, the element  $a_{ij}$  of the matrix refers to the relative importance of the  $i^{\text{th}}$  factor in response to the  $j^{\text{th}}$  factor yielding an  $n \times n$  matrix A as follows:



$$A = [a_{ij}] = \begin{matrix} & \begin{matrix} C_1 & C_2 & \dots & C_n \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} & \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & & a_{2n} \\ \vdots & & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix} \end{matrix} \quad (Eq.1)$$

$$1 \leq i, j \leq n$$

Here,  $a_{ii} = 1$  and  $a_{ij} = 1/a_{ji}$  for all  $i, j = 1, 2, 3 \dots n$ . Therefore assigning the elements  $C_1, C_2, \dots, C_n$  to the numerical weights  $W_1, W_2, \dots, W_n$ , reflects the recorded respondent judgments obtained. For example, from the Saaty's scale value of 1-9 in Table 1, if a respondent compares two elements, exploration/production risk ( $C_1$ ) to environmental and regulatory compliances risk ( $C_2$ ) and specified that  $C_1$  is very strongly more important than  $C_2$  then the numerical weight assigned to this pairwise comparison,  $a_{12} = 7$ , indicating that  $C_1$  is 7 times more important than  $C_2$ , for all  $a_{ij} = 1$ . However, if  $a_{ij} = \alpha$  then for consistency, it is required that  $a_{ji} = 1/\alpha$ . Therefore, if  $a_{12} = 7$ , then  $a_{21} = 1/7$  must hold.

2. Due to reciprocity, the application of the AHP, requires that if  $a_{ij} = \alpha$ , then  $a_{ji} = 1/\alpha$ , with  $1/9 \leq \alpha \leq 9$ . Since the matrices of the pairwise comparisons of an element at one level determine the achievement of the preceding level's objectives, the pairwise comparisons of the attributes at level 2 with one another in relation to their importance to the objective at level 1 in the hierarchy will require only  $n(n-1)/2$  comparisons to build the matrix with a dimension  $n \times n$ . Therefore, in the case of the petroleum industry, at level 2, the pairwise comparisons of the six attributes (risk factors) will result in a  $6 \times 6$  pairwise comparison matrix.

Then at level 3, for each of the 6 attributes, the same procedure when used for pairwise comparison of the three alternatives will result in six matrices of size  $3 \times 3$ . When the input matrices of the respondent's judgments are compared to themselves, the principal diagonal elements are all at unity, confirming that each element has equal importance. Therefore, if the elements  $i$  and  $j$  are judged to be equally important, then  $a_{ij} = a_{ji}$  and  $a_{ii} = 1$ , indicate that the lower triangle elements of the matrix are now the reciprocals of the upper triangle elements.

3. The AHP measures how consistent the evaluator's judgment is, by utilizing the consistency ratio

(CR), which is the ratio of the consistency index over random index. Considering  $A$  as a consistency matrix, the relations between weight  $W_i$  and judgments  $a_{ij}$  are represented as  $W_i/W_j = a_{ij}$  (for all  $i, j = 1, 2 \dots n$ ) with assigned relative weight entering the matrix as an element  $a_{ij}$ , with a reciprocal entry  $1/a_{ij}$  at the opposite side of the main diagonal will present the matrix of the pairwise comparison as follows:

$$A = [a_{ij}] = \begin{matrix} & \begin{matrix} W_1/W_1 & W_1/W_2 & W_1/W_n \end{matrix} \\ \begin{matrix} W_2/W_1 & W_2/W_2 & W_2/W_n \\ W_n/W_1 & W_n/W_2 & W_n/W_n \end{matrix} & \end{matrix} \quad (Eq. 2)$$

AHP stipulates that since the evaluators do not necessarily know the vector of the actual relative weights, it is difficult to accurately construct the pairwise comparison of the relative weights of matrix  $A$ , rendering this observed matrix  $A$  to have inconsistencies. Several estimations made by evaluators may have created series of inconsistencies that need to be checked. Therefore, the weight  $W$  can be estimated from the following equation:

$$\Delta A * \Delta W = \lambda_{\max} * \Delta W \quad (Eq.3)$$

Where  $\Delta A$  denotes the observed matrix of pairwise comparisons,  $\lambda_{\max}$  is the maximum or principal eigenvalue of  $\Delta A$  and  $\Delta W$  is the vector estimator of  $W$ . According to Saaty (1980) since the maximum eigenvalue  $\lambda_{\max}$  is always greater than or equal to  $n$  (the number of elements) it should be an acceptable estimator of  $n$ . Conversely, when the observed value of  $\Delta A$  is consistent, the value of the maximum eigenvalue  $\lambda_{\max}$  is always greater than or very

close to  $n$ , allowing for the construction of the consistency index CI, and consistency ratio CR as follows:

$$CI = (\lambda_{\max} - n) / (n - 1) \quad (\text{Eq.4})$$

$$CR = (CI / ACI) * 100. \quad (\text{Eq.5})$$

Here ACI represent the average index of randomly generated weights. The AHP measures how consistent the evaluator's judgment is by utilizing the consistency ratio (CR), which is the ratio of the consistency index over the random index (RI) using equations 4 and 5 and the approximated random indices from Table 2.

Table.4: Approximated Saaty's AHP Random Indices (RI).

Size of matrix (n)	1	2	3	4	5	6	7	8	9	10
Random Indices(RI)	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

A consistency ratio (CR) which estimates the extent of inconsistency in each pairwise comparison matrix must be below a specific threshold. According to Saaty (1980), a deviation in consistency ratio of less than .10 or 10% is acceptable without adverse effect on the result, but considered to be inconsistent if greater than .10 or 10% and therefore the judgment is expected to be revised.

4. Aggregating the weights of the decision elements to provide a set of ratings for the decision alternative. Finally, the sensitivity analysis option of the Expert Choice enables the decision maker to graphically explore to what extent the overall priorities are sensitive to changes in the relative importance (weight) of each attribute or criteria.

### Data Collection

In order to achieve the objectives of this study a survey questionnaire technique approach was used to collect data to specify the order of importance of the upstream petroleum supply chain risks. The questionnaire

was designed to collect opinion of subject matter expert (Risk Managers) in the petroleum industry requiring them to respond to several pairwise comparisons where two categories at a time are compared with respect to the major goal.

Geometric mean scores were computed from the individual expert scores on Saaty's 1-9 scale provided by the petroleum executives. The Expert Choice 11.5 software package (2000-2004) based on AHP is used to estimate the weights of importance of the six major risk, as well as test the inconsistency among the individual expert's preferences. These judgments are entered employing Saaty's pairwise comparison scale in Table 5. The decision makers evaluate each criterion against all others and values of relative importance is assigned to more important criteria and the reciprocal to the lesser important. For example, comparing the geometric mean values of geopolitical risk to all other risk criteria, it shows the lowest value, indicating less important risk for the petroleum industry to manage.

Table.5: Geometric Mean of Combined Experts' Judgment Pairwise Comparison Matrix of Major Objectives with Respect to the Goal

	Exploration/ Production Risk	Environmental and Regulatory Compliance Risk	Transportation Risk	Availability of Oil Resource Risk	Geopolitical Risk	Reputational Risk
Exploration/ Production Risk	1	1.231144	1.048122	1.490182	2.085348	1.799592
Environmental and Regulatory						

Compliance Risk	.812252	1	.0581811	.933033	1.334188	1.474768
Transportation Risk	.954087	1.718772	1	2.724154	2.839053	1.987134
Availability of Oil Resource Risk	.671059	1.071773	.51186	1	1.533675	1.533675
Geopolitical Risk	.479536	.686201	.35223	.652029	1	.797577
Reputational Risk	.691503	.835959	.578068	.698827	1.253797	1

## V. EMPIRICAL RESULT

### Data Analysis

The pair-wise comparison of all the risk criteria generates a priority matrix as given in table 5, which shows that Transportation Risk (.263), Exploration/Production Risk (.198) and Environmental/Regulatory Compliance Risk (.161) are the top three major risk areas in the upstream petroleum supply chain, followed by availability of oil resource risk (.150), reputational risk (.124) and geopolitical risk (.105).

Table.6: Priority Matrix for the Major Objectives

Objective	Priority	Rank
Transportation Risk	.263	1
Exploration /Production Risk	.198	2
Environmental and Regulatory Compliance Risk	.161	3
<b>Availability of Oil Resource Risk</b>	.150	4
Reputational Risk	.124	5
Geopolitical Risk	.105	6
Inconsistency Ratio	<b>0.03</b>	

### Sensitivity Analysis for Major Decision Objectives

The sensitivity analysis option of Expert Choice Software enables the decision maker to graphically explore the response of the overall alternative policy options and changes in the relative importance (weight) of each attribute or criterion. This is an important aspect of using AHP in analyzing problems, since results are based on subjective expert assessments. A series of sensitivity analyses were conducted using Expert Choice Software includes 1) performance, 2) gradient, 3) dynamic, 4) head to head, and 5) two-dimensional plots. Each of these five graphical modes expresses different viewpoint to a sensitivity analysis, enabling the user to easily manipulate the criterion priorities and instantly observe the impact of the change that is reflected in the ranking of alternative.

### Performance Sensitivity Analysis

The performance sensitivity analysis depicted in Figure 1 represents the variation of the alternative policies' rankings to changes in each criterion. It shows the ratio of each alternative's weight percentage to criteria weights.

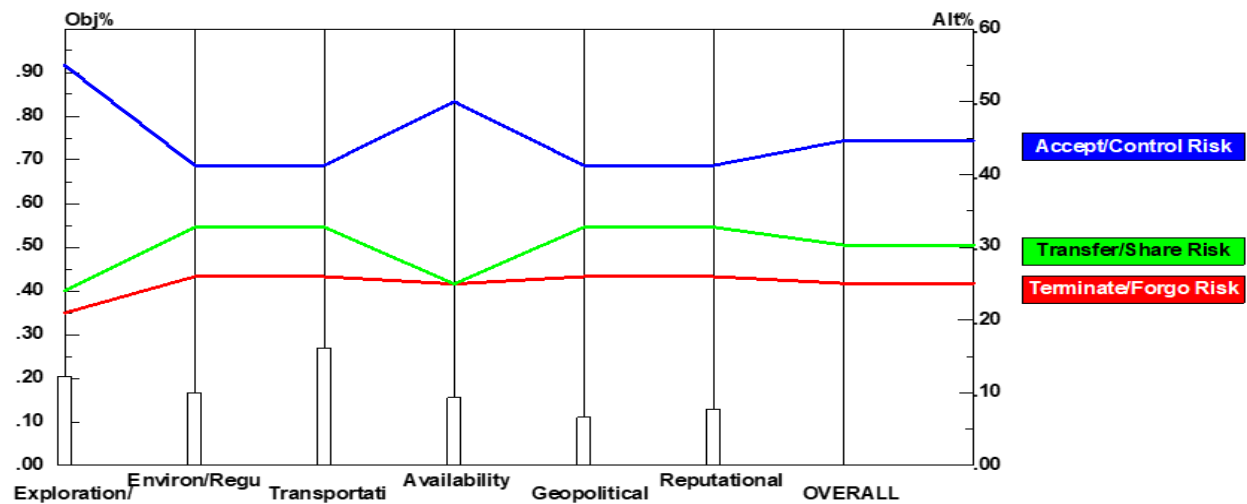


Fig.5: Performance Sensitivity Analysis.

Determining the best risk mitigating strategy, the decision maker will read the overall priority from the observation of the right “y”-axis and the overall priority for each alternative risk management strategy. The right “y” axis represents the overall priority of each alternative (with the OVERALL axis showing the overall priority of each criterion). The result shows that accept and control risk is about .45 (45%), transfer or share risk is about .31 (31%), and terminate or forgo risk is about .25 (25%). The vertical bars represent the derived relative priorities of each criterion. The left “y” axis represents the relative priority of each criterion as synthesized from the expert’s pairwise comparisons. Based on the result, exploration and production risk is about .20 (20%), environmental and regulatory compliance risk is about .18 (18%), transportation risk is about .28 (28%), availability of oil resource risk is about .16 (16%), geopolitical risk is about .10 (10%), while reputational risks is about .11 (11%). In reference to alternative policy priorities with respect to each major objective while reading from the right “y” axis, with respect to exploration and production risk, accept and control risk is about .91 (91%), transfer or share risk is approximately .40 (40%), and terminate or forgo activity is about .35 (35%). For environmental and regulatory compliance risk, accept

and control risk is about .70 (70%), transfer or share risk is approximately .55 (55%), while terminate or forgo activity is about .42 (42%). Regarding transportation risk, accept and control risk is about .70 (70%), transfer or share risk is about .55 (55%), and terminate and forgo activity is about .40 (40%). With respect to availability of oil resource risk, accept and control risk is about .85 (85%), transfer or share risk is about .40 (40%), and terminate or forgo activity is about .40 (40%). For geopolitical risk, accept and control risk is about .70 (70%), transfer and share risk is about .55 (55%), while terminate or forgo activity is about .41 (41%). With respect to reputational risk, accept and control and transfer is about .71 (71%), transfer and share risk is about .55 (55%), while terminate and forgo is about .40 (40%). Finally, for the overall, accept and control risk is about .75 (75%), which is still the best risk mitigation strategy followed by transfer or share risk which is about .30 (30%), and then terminate or forgo activity at about .25 (25%). It can be seen in Figure 6-A scenario 1 that changing the criterion value with respect to environmental and regulatory compliance risk from .18 to .30 does not change the ranking of the alternatives, and that accept, and control risk still remain the number one alternatives.

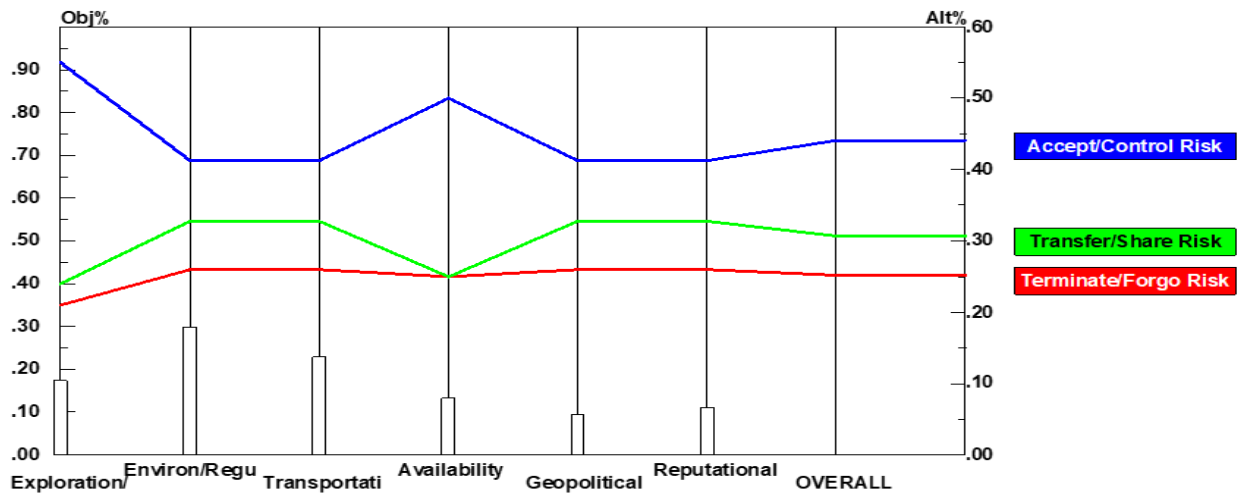


Fig.6-A. Performance Sensitivity Analysis: Scenario 1. With Respect to Environmental and Regulatory Compliance Risk.

It can be seen in Figure 6-B scenario 2, that changing the criterion value with respect to transportation risk from .28 to .35 did not change the ranking of the alternatives and that accept, and control risks still remain the number one

alternative. However, upon conducting the sensitivity analysis for the rest of the decision criterion such as availability of oil resource risk, the rankings still remain insensitive.

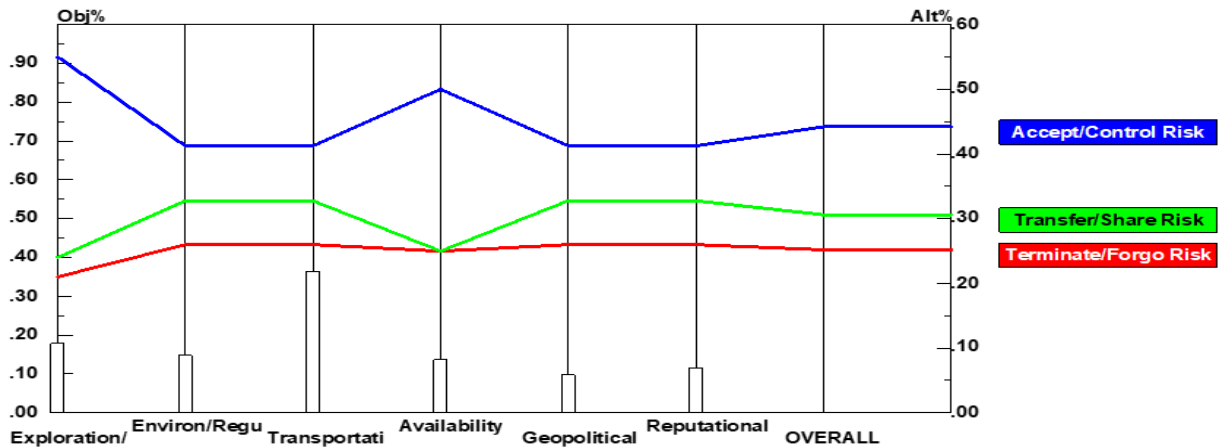


Fig.6-B: Performance Sensitivity Analysis: Scenario 2. With Respect to Transportation Risk

## VI. SUMMARY AND CONCLUSION

Risk is defined as a potential future event that may influence the achievement of objectives; that includes upside and downside risks. Effective risk management increases the value of business decisions because conscious choices are made in relation to risks that have an impact on, or result from, these business decisions. The objective of risk management is not, therefore, arbitrarily to reduce or eliminate risk. In general, many people are involved in

managing risk, and risk management, which is an integral part of the group's management activities (strategy, planning, execution, operation, monitoring, and appraisal); it is not a separate activity. Risk management is the responsibility of those who are accountable to deliver the associated objective; therefore, the identification of the risk can only have value or meaning when explicitly linked to the objective.

This research involves the evaluation of the actual oil industry to identify and select an appropriate upstream



crude oil supply chain risk management model leveraging analytic hierarchy process (AHP). The AHP provides a framework to cope with multiple criteria situations involving intuitive, rational, quantitative, and qualitative aspects. This study shows that the AHP is appropriate for developing such a model. It organizes the basic rationality by breaking down a problem into its smaller constituent parts, and then guides the decision maker through a series of pairwise comparison judgments to express relative strength or intensity of impact of the elements of the hierarchy. The AHP methodology is a flexible tool that can be applied to any hierarchy of performance measure; in addition, the AHP model is effective in decision making. The most essential goal of this research is to identify the potential risk sources, model the risk management, analyze and evaluate the potential impact of risks, and propose risk treatment in terms of the most important risk to manage and finally select the appropriate alternative options to minimize, such as accept and control risk, terminate or forgo activity, and transfer or share risk.

To achieve the objectives of the research, a survey questionnaire approach was used to collect data to specify the order of importance of the upstream crude oil supply chain risks. The questionnaire was designed to collect opinion of subject matter expert (risk managers) in the oil industry. The result of the survey questionnaire was used as input to the AHP, and the result of the pairwise comparison of the major objective indicates that the most important risk to minimize and manage in the oil industry is transportation risk with priority of .263 (26.3%). This verifies the fact that transportation in the petroleum supply chain is the central logistic that links the upstream and downstream functions, playing a crucial role in the global supply chain management in the oil industry.

Exploration/production and environmental and regulatory compliance risk are also identified as major risk factors with priorities of .198 (19.8%) and .161 (16.1%) respectively. With respect to major objectives or goals, the most preferable risk management policy option based on the result of the composite score is accept and control risk with a score of .446 (44.6%) followed by transfer or share risk at .303 (30.3%). The least likely is terminate or forgo activity .251 (25.1%). In most comparison processes it is obvious that some inconsistencies would occur. However, Saaty (1980) specifies that an inconsistency ratio of about .10 (10%) or less may be considered acceptable without adverse effect on the result. The overall inconsistency ratio for the aggregate response is .03 which is below the Saaty's recommended threshold for an acceptable inconsistency.

However, the results also indicate inconsistency ratios for the different decision alternatives. With respect to; transportation risk inconsistency is .05, exploration and production risk is .02, environmental and regulatory compliance risk is .05, availability of oil resource risk is 0.0, reputational risk is .05 while geopolitical risk is .05. Overall, the respondent judgments indicate reliable expert judgment.

To gain more in-depth insight of the problem and result, sensitivity analysis options of the Expert Choice Software was performed to further study the effect of changing the weights of criteria on the overall weight of the alternatives. The results of such analyses also indicate that transportation risk is most prominent while accepting and controlling risk is also the most prominent alternative risk management option. In the oil industry, accepting and controlling risk for example; reputational risk became an issue as a result of oil spill. Companies in the oil industry have a long history of neglecting environmental issues but consequently as a result of public outcry, accepted the risk of oil spill and put in place some appropriate controls to reduce their reputational risk as much as possible. Transportation risk in the oil industry could be managed to an acceptable level. However, these companies in the industry today deal with several issues such as; globalization, regulatory compliance, increased environmental pressures, mergers and acquisitions that combine make operational risk management a complex and difficult task for the oil industry.

According to Ariel Cohen (2007), Two-thirds of the world's oil reserves are concentrated in the increasingly unstable Middle East and are controlled by members of the quasi-monopolistic Organization of Petroleum Exporting Countries (OPEC). Over the years, OPEC has been quick to cut supply and slow to increase production, bringing oil prices to today's high levels. Most OPEC member countries and other oil producers have high levels of government economic regulation and corruption, as documented in the *Index of Economic Freedom*, published by The Heritage Foundation and *The Wall Street Journal*. Thus, consumers are effectively paying two premiums on oil—one for security and one for suppliers' economic inefficiency and monopolistic behavior. Collaborative interest can also mean collective security and corporate protection of the flow of oil, which benefits both producing and consuming nations. A shortfall or slack in this endeavor may play into the hands of insurgents and international terrorists that seek to alienate, divide, and defeat national interests, especially industrialized western nations. Considering the importance of the oil

supply risk issue, a number of future potential research areas can be recognized to achieve an integral examination of the subject area. In fact the quantification and assessment of each risk's probabilities might be an important and demanding task that probably has never been attempted. This might also be true for the impact of each of the risks as well. Recent events have suggested that greater clarity is needed in terms of who is responsible for managing risks, especially transportation and exploration/production and availability of oil resource risk.

This study has opened the door for further studies to be conducted and to investigate the risk impact on other sectors of the oil industry.

### REFERENCES

- [1] Alberto, P. (2000). The Logistics of Industrial Location Decision: An Application of the Analytical Hierarchy Process Methodology. *International Journal of Logistics: Research and Application*, 3(3), 273-289.
- [2] Al-Thani, F. (2008). *The Development of Risk Management in the GCC Oil and Gas Sector*. Retrieved October 15, 2018, from [http://www.theirm.org/events/documents/DrFaisalAlThani\\_ImportanceofRiskManagement-9NOV-QATAR.pdf](http://www.theirm.org/events/documents/DrFaisalAlThani_ImportanceofRiskManagement-9NOV-QATAR.pdf).
- [3] American Petroleum Institute. (2005). *Security Guidelines for the Petroleum Industry*.
- [4] Ariel Cohen (2007). The National Security Consequences of Oil Dependency: The Heritage Foundation
- [5] Ariel Cohen (2007). Foreign Policy & National Security Implication of Oil Dependence; pp: 38 The 11 OPEC members are Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.
- [6] Ariel Cohen, and William Schirano, (2005)"Congress Should Lift OPEC's Immunity," Heritage Foundation *Web Memo* No. 777.[www.heritage.org/Research/EnergyandEnvironment/wm777.cfm](http://www.heritage.org/Research/EnergyandEnvironment/wm777.cfm). For example, in terms of economic freedom, Iran, Venezuela, and Nigeria were ranked 156th, 152nd, and 146th out of 157 countries, respectively.
- [7] Marc A. Miles, Kim R. Holmes, and Mary Anastasia O'Grady, 2006 *Index of Economic Freedom* (Washington, D.C.: The Heritage Foundation and Dow Jones & Company, Inc., 2006), at [www.heritage.org/index](http://www.heritage.org/index).
- [8] BBC News. (2008, July 7). Global Oil Industry in Figure. Retrieved on January 18, 2009, from <http://www.news.bbc.co.uk/2/hi/business/7090664.stm>.
- [9] Belton V., & Gear, T. (1985). The Legitimacy of Rank Reversal-a Comment. *Omega*, 13(3), 143-144.
- [10] B. P. (2008). *BP Statistical Review of World Energy*. Retrieved July 2018, from [http://www.bp.com/liveassets/bp\\_internet/globalbp/globalbp\\_uk\\_english/reports\\_and\\_publications/statistical\\_energy\\_review\\_2008/STAGING/local\\_assets/2009\\_downloads/oil\\_table\\_proved\\_oil\\_reserves\\_2009.pdf](http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2009_downloads/oil_table_proved_oil_reserves_2009.pdf).
- [11] Blum, H., & Legey, L.F.L. (2012). The challenging economics of energy security: Ensuring energy benefits in support to sustainable development. *Energy Economics*, 34(6), 1982-1989. doi: <http://dx.doi.org/10.1016/j.eneco.2012.08.013>
- [12] Briggs, C, Tolliver, D, & Szmerekovsky, J. (2012) Managing and Mitigating the Upstream Petroleum Industry Supply Chain Risks: Leveraging Analytic Hierarchy Process.
- [13] Briggs, C (2017) Maritime Piracy: 'A Disruptive Implication for Global Oil Transportation Security'
- [14] Chan, F. T. S. (2003). Interactive Selection Model for Supplier Selection Process: An Analytical Hierarchy Process Approach. *International Journal of Production Research*, 41(15), 3549-3579.
- [15] Christian, A. (2003). *Fuelling Poverty – Oil, War and Corruption*. Retrieved on January 15, 2009, from <http://www.kub.biz/print.php?sid=3715>.
- [16] Cohen, A. (2007). The National Security Consequences of Oil Dependency.
- [17] Dey, P. K., (2001). Integrated Approach to Project Feasibility Analysis: A Case Study, Impact Assess. *Project Appraisal*, 19(1), 135-245.
- [18] Dey, P. K. (2004b). Decision Support System for Inspection and Maintenance: A Case Study of Oil Pipelines. *IEEE Transactions on Engineering Management*, 51(1), 47-56.
- [19] Dey, P. K., Tabucanon, M. T., Ogulana, S. O., & Gupta, S. S. (2001). Multiple Attribute Decision Making Approach to Petroleum Pipeline Route Selection. *International Journal for Services Technology Management*, 2(3/4), 347-362.
- [20] Dimitrova, D., & Lo'pez, S. (2005). *Volatility in Oil Firms and Risk Management*. Master Thesis.Göteborg University, Sweden.
- [21] Dyer, J. S., & Wendel, R. E. (1985). *A Critique of the Analytic Hierarchy Process*. Working paper, 84/85-4-24, Department of Management, The University of Texas at Austin. Retrieved on March 16, 2009, from <http://www.edf.org/pressrelease.cfm?contentID=1453>.
- [22] Energy Information Administration. (2010). *Short-Term Energy Outlook: February 2010*. Retrieved on November 15, 2018, from [http://www.eia.doe.gov/steo#Global\\_Crude\\_Oil\\_And\\_Liquid\\_Fuels](http://www.eia.doe.gov/steo#Global_Crude_Oil_And_Liquid_Fuels)
- [23] Faisal, M. N., Banwet, D. K., & Shankar, R. (2006b). Supply Chain Risk Mitigation: Modeling the Enablers. *Business Process Management Journal*, 12(4), 535- 552.
- [24] Fattouh, B. (2006). Spare Capacity and Oil Price Dynamics. *Middle East Economic Survey*, XLIX.

- [25] Fattouh B. (2007). How Secure are Middle East Oil Supplies? Oxford Institute for Energy Studies 33.
- [26] Felix, T. C. & Niraj, K.(2005). Global Supplier Development Considering Risk Factors Using Fuzzy Extended AHP-Based Approach. *Omega* 35(4), 417-431.
- [27] Gary, I. & Karl, T. L. (2003). Bottom of the Barrel: Africa's Oil Boom and the Poor. CRS Report.
- [28] Ghoshal, S. (1987). Global Strategy: An Organizing Framework. *Strategic Management Journal*, 8, 425-440.
- [29] Goslin, C. (2008). *International Petroleum Industry Security System*. White Paper. Retrieved on August 15, 2018, from <http://www.duostechologies.com/DownloadCenter/WP-InternationalPetroleumIndustry.pdf>.
- [30] Grant, K., Ownby, D., & Peterson, S. R. (2006). Understanding Today's Crude Oil and Product Markets. A Policy Analysis Study by Lexecon, an FTI Company, Undertaken for API. Retrieved in November 10, 2009 from, [http://www.heartland.org/policybot/results/19500/Understanding\\_Todays\\_Crude\\_Oil\\_and\\_Product\\_Markets.html](http://www.heartland.org/policybot/results/19500/Understanding_Todays_Crude_Oil_and_Product_Markets.html).
- [31] Haimes, Y. Y. (1998). *Risk Modeling, Assessment and Management*. New York: John Wiley and Son, Inc.
- [32] Harker, P. T., & Vargas, L. G. (1987). The Theory of Ratio Scale Estimation: Saaty's Analytic Hierarchy Process. *Management Science*, 33(1), 1383-1403.
- [33] Hussain, A. (2006). Security of Oil Supply and Demand and the Importance of the Producer-Consumer Dialogue. *Middle East Economic Survey*, XLIX(50).
- [34] International Labor Organization. (2002). *Oil and Gas Production; Oil Refining*. Retrieved on January 9, 2019, from <http://www.ilo.org/public/english/dialogue/sector/sectors/oilgas.htm>.
- [35] Iwan V., Suhaiza Z., Nyoman, P. (2009). Supply Chain Risk Management: Literature Review and Future Research. *International Journal of Information Systems and Supply Chain Management*, 2(1), 16-33.
- [36] Kalicki, J. H., Goldwin, D. L. (eds.). (2005). *Energy and Security- Toward a New Foreign Policy Strategy*. Washington, D.C.: Woodrow Wilson Center Press.
- [37] Karl, T. L. (1997). *The Paradox of Plenty: Oil Boom and Petro-States*. Berkeley: University of California Press.
- [38] Katz, M. et al. (2004). Lifting the Oil Curse, IMF.
- [39] Keith, M. (2005). Petroleum, Poverty and Security; African Programme, Chatham House.
- [40] Khatib, H. (2000). *World Energy Assessment: Energy and the Challenge of Sustainability*.
- [41] Klare, M. (2004). *Blood and Oil: The Dangers and Consequences of America's Growing Petroleum Dependency*. New York: Metropolitan Books.
- [42] Kleveman, L. (2003). *The New Great Game: Blood and Oil in Central Asia*. Atlantic Books.
- [43] Lalwani, C. S., Disney, S. M., & Naim, M. M. (2006). On Assessing the Sensitivity to
- [44] Uncertainty in Distribution Network Design. *International Journal of Physical Distribution & Logistics Management*, 36(1), 5-21.
- [45] Levy, J. & Gopalakrishnan, C. (2009). Multicriteria Analysis for Disaster Risk Reduction in Virginia, USA: A Policy-Focused Approach to Oil and Gas Drilling in the Outer Continental Shelf. *Journal of Natural Resources Policy Research*, 1(3), 213-228.
- [46] Liu, F. H. F., & Hai, H. L. (2005). The Voting Analytic Hierarchy Process Method for Selecting Supplier. *International Journal of Production Economics* 97(3), 753-758.
- [47] Marcel, V. (2006). Oil Titans. Washington, D.C.: Brookings Institute. Retrieved on January 12, 2019, from <http://www.mbendi.co.za/indy/oil/p0005.htm> and <http://www.mbendi.com/indy/oil/p0005.htm>.
- [48] McPherson, C. (2003). National Oil Companies: Evolution, Issues, Outcomes in Fiscal Policy Formulation and Implementation in the oil-Producing Countries.
- [49] Miller, K. (1992). A Framework for Integrated Risk Management in International Business. *Journal of International Business Studies*, 23(2), 311-331.
- [50] Mitchell G. Bard, (M Bard 2006) "Middle East Policy and Oil," Jewish Virtual Library, at [www.jewishvirtuallibrary.org/jsource/US-Israel/usoil.html](http://www.jewishvirtuallibrary.org/jsource/US-Israel/usoil.html) (November 29, 2018).
- [51] Mitchell, J. V. (2002). Renewing Energy Security. The Royal Institute for International Affairs, Sustainable Development Programme.
- [52] Moody-Stuart, M. (2003). The Curse of Oil. *Geoscientist*, 13(7), 10-13.
- [53] Munk, B. E. (2005). *The End of Cheap Oil, Once Again: Geopolitics or Global Economics?* Foreign Policy Research Institute.
- [54] Mustafa, M. A., & Ryan, T. (1990). Decision Support for Bid Evaluation. *International Journal of Project Management*, 8(4), 230-235.
- [55] Nataraj, S. (2005). Analytic Hierarchy Process as a Decision-Support System in the Petroleum Pipeline Industry. *Issues in Information Systems*, 6(2), 16-21.
- [56] Noronha, L. (2005). *The problem*. Center for Research on Energy Security: The Energy and Research Institute, (TERI) Delhi. Retrieved on January 6, 2019, from <http://www.india-seminar.com/2005/555/555%20the%20problem.htm>.
- [57] Niall, McCarthy. (2018) Statista Portal [www.statista.com/chart/4284/the-economies-most-dependent-on-oil/](http://www.statista.com/chart/4284/the-economies-most-dependent-on-oil/)

- [58] Opoku, B. P. (2009). Our Oil and its Security. Retrieved November, 2018 from <http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php>
- [59] O'Rourke, D., & Connolly, S. (2003). Just Oil? The distribution of environmental and social impacts of oil production and consumption. *Annual Review of Environment and Resources*, 28, 578-617.
- [60] Perez, J. (1995). Some Comments on Saaty's AHP. *Management Science*, 41(6), 1091-1095.
- [61] Petroleum Sector Briefing (2007, March). Note No. 1. Retrieved October 18, 2018 from [http://www.siteresources.worldbank.org/INTOGMC/Resources/cambodia\\_oil\\_gas\\_newsletter\\_1.pdf](http://www.siteresources.worldbank.org/INTOGMC/Resources/cambodia_oil_gas_newsletter_1.pdf)
- [62] Pirog, R. (2007, August). *The Role of National Oil Companies in the International Oil Market*. Congressional Report Service (CRS) Report for Congress.
- [63] Pocha, J. 2005. Rising China: The GeoPolitics of Oil. *National Policy Quarterly*. Winter:50-56.
- [64] Rangone, A. (1996). An Analytic Hierarchy Process Framework for Comparing the Overall Performance of Manufacturing Departments. *International Journal of Operations and Production Management*, 16, 104-119.
- [65] Rooyen, J. Van; & Solomon Hussein (2007). The Strategic Implications of the US & China's Engagement within Africa. *Scientia Militaria, South African Journal of Military Studies*, Vol 35, Nr 1, 2007. doi: 10.5787/35-1-27
- [66] Ross, M. (2001). *Extraction Sectors and the Poor*. Boston: Oxfam Am.
- [67] Ruud, W., & Jon, V. (2008). Cultural Challenges in Oil and Gas Industry Management: Delft University of Technology and Energy Delta Institute, Groningen, and Kooi kay Van der. University of Groningen. Retrieved on December 18, 2018, from <http://www.energydelta.nl/repository/sitecontent/Cultural%20challenges%20in%20oil%20and%20gas%20industry%20management%20-%20april%202008.pdf>.
- [68] Saaty, T. L. (1980). *The Analytical Hierarchy Process: Planning, Priority Setting, Resource Allocation*. (1<sup>st</sup> ed.). New York: McGraw-Hill.
- [69] Saaty, T. L. (2000). *Fundamentals of Decision Making and Priority Theory*. (2<sup>nd</sup> ed.). Pittsburgh, PA: RWS Publications.
- [70] Saaty, T. L., & Kearns, K. P. (1985). *Analytical Planning: The Organization of Systems*. Pergamon Press.
- [71] Salas, C. (2009, February). *Geography of Petroleum and its Distribution: An Overview of Petroleum Geography*. Retrieved on September 11, 2018, from <http://www.Geography.about.com/petroleumgeog>
- [72] Shaunak, A. (2007). Geopolitical Risk and Oil. Retrieved on September 30, 2018, from <http://www.shunak.wordpress.com/2007/09/12/geopolitical-risk-and-oil/>.
- [73] Shaxson, N. (2005). Oil – The Resource Curse. *International Affairs*, 81(2), 311–24.
- [74] Siddharth, V., Subhash, W., & Deshmukh, S. G. (2007). Evaluating Petroleum Supply Chain Performance. Application of Analytic Hierarchy Process to Balanced Scorecard. *Asia Pacific Journal of Marketing and Logistics*, 20 (3), 343 – 356.
- [75] Srividhya, V. S., & Raj, J. (2007). Management of Supplier Risks in Global Supply Chains. *SETLabs Briefings*, 5(3). Retrieved on June 19, 2018, from <http://www.infosys.com/supply-chain/white-papers/documents/management-suppliers-risk-setlabs.pdf>.
- [76] Statement on Global Energy Security Principles. Communique of the G-8. St Petersburg, Russia, 16 July 2006. [Online] <http://www.eni-g8russia.ru/docs/11/html>. (January 8 2019).
- [77] Steinhausler, F., Furthner, P., Heidegger, W., Ryndell, S., & Zaitseva, L. (2008). Security Risks to the Oil and Gas Industry: Terrorist Capabilities. *Strategic Insights. Center for Contemporary Conflict*, 7(1). Retrieved on October 12, 2018, from <http://www.nps.edu/Academics/centers/ccc/publications/OnlineJournal/2008/Feb/steinhauslerFeb08.pdf>.
- [78] Stern, J. (2002). The impact of import Dependence and Liberalization. Security of European National Gas Supplies. The Royal Institute of International Affairs, Sustainable Development Programme.
- [79] Stevens, P. (2003). Resource Impact: A Curse or a Blessing? *CEPMLP Online Journal* 14(1).
- [80] Stevens, P. (2008). National Oil Companies and International Oil Companies in the Middle East: Under the Shadow of Government and the Resource Nationalism Cycle. *Journal of World Energy Law and Business* 1(1), 5-30.
- [81] Stratfor Global Intelligence. (2006). Saudi Arabia: Abqaiq Attack Thwarted. Retrieved on July 20, 2018, from [http://www.stratfor.com/saudi\\_arabia\\_abqaiq\\_attack\\_thwarted](http://www.stratfor.com/saudi_arabia_abqaiq_attack_thwarted).
- [82] Tam, M. C. Y., & Tummala, V. M. R. (2001). An Application of the AHP in Vendor Selection of a Telecommunications System. *Omega*, 29, (2), 171-182.
- [83] U.S. Department of State. (1976). The Second Arab Embargo, (1973-1974). Retrieved on July 30, 2018, from <http://www.state.gov/r/pa/ho/time/dr/96057.htm>
- [84] Umbach, F. 2004. Global Energy Supply and Geopolitical Challenges. In: François Godement, Françoise Nicolas, and Taizo Yakushiji, eds. 2004. Asia and Europe – Cooperating for Energy Security. Massachusetts: Brookings Institution. 137-168.
- [85] Van der Linde, C. (2000). *The State and the International Oil Market: Competition and the Changing Ownership of Crude Oil Assets*. Boston: Kluwer Academic Publishers.
- [86] Weisser, H. (2005). The security of gas supply, A critical Issue for Europe, *Energy Policy*, 35(1), 1-5.

- [87] World Economic Forum (2016) Which Economies are most reliant on oil.
- [88] <https://www.weforum.org/agenda/2016/05/which-economies-are-most-reliant-on-oil/> Retrieved January 2019.
- [89] Wolf, C. (2008). *Does Ownership Matter? Cross-Sectional Evidence on State Oil vs. Private Oil (1987-2006)*. University of Cambridge.
- [90] World Bank data (2012). World oil revenue as share of GDP
- [91] Yergin, D. (2006). Ensuring Energy Security. *Foreign Affairs*.