Past, Present and Future Evolution of Oil Prices

by

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Master of Science in Mechanical Engineering, ParisTech-ENSAM, France, 1996

Submitted to the MIT Sloan School of Management
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ABSTRACT

This thesis reviews how oil price has evolved throughout time since it was discovered and commercially exploited in 1859 in Pennsylvania. Rather than a pure economic study, this thesis illustrates how major historic and geopolitical events have been influenced or driven by a frantic quest for oil. Oil has allowed the automotive industry to thrive, the industrial revolution to shift gears and has fueled economic growth especially in the USA and the western countries throughout the twentieth century. Oil has also played a major strategic role during WWI and WWII. More recently, Oil has also been used as an economic weapon in several occasions. During the first and the second oil crises, producing countries have created OPEC in order to control prices in an attempt to get autonomy from consuming countries who had historically manipulated the prices thanks to the "Seven Sisters" regrouped in an illegal but extremely powerful "Oil Cartel". In the 1980's Reagan's Administration has successfully used oil as an economic weapon to fight the Soviet Union which eventually collapsed. With "Peak Oil" now approaching (some say already reached) oil prices are more and more difficult to manipulate. As supply now struggles to match demand, oil prices are more and more driven by macroeconomics fundamentals but this doesn't mean that speculation has no impact as we have seen recently during the 2007-2008 bubble. To end with, this thesis concludes showing that if the past evolutions of oil prices are pretty well understood, predicting future prices is an exercise that requires utter humility.

Thesis Advisor: Alex Stomper, *MIT Sloan visiting Assistant Professor of Finance*

Acknowledgements

I would like to thank Professor Alex Stomper and Professor John E. Parsons for their help throughout the preparation and the drafting of this thesis despite their respective very busy schedules. Without their support, this project would not have been possible.

In addition, I also would like to thank MIT Sloan Administration, especially Heather Dill, Chanh Phan and Scott Alessandro for their support and understanding.

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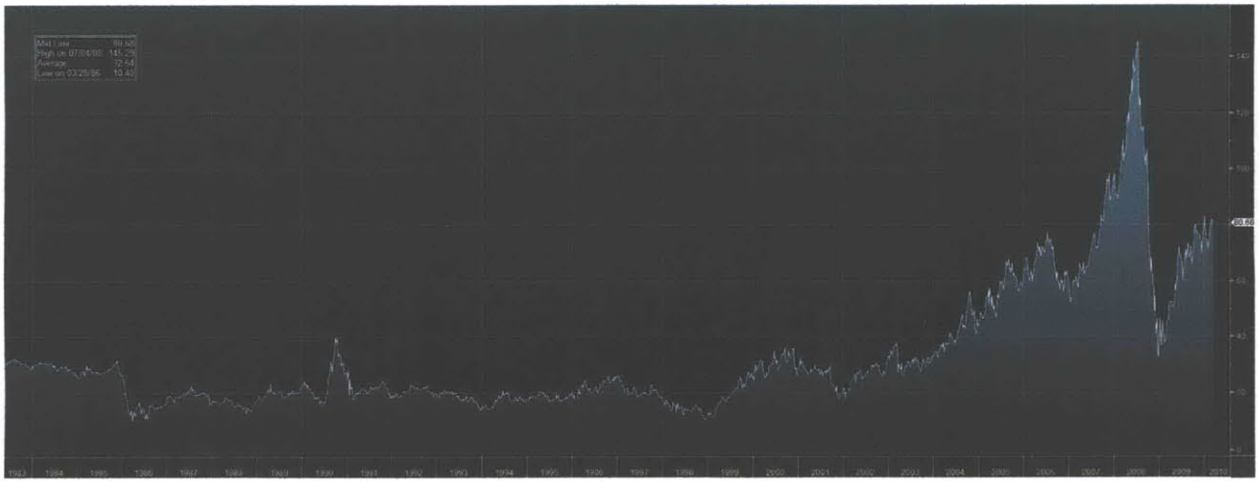
Preface

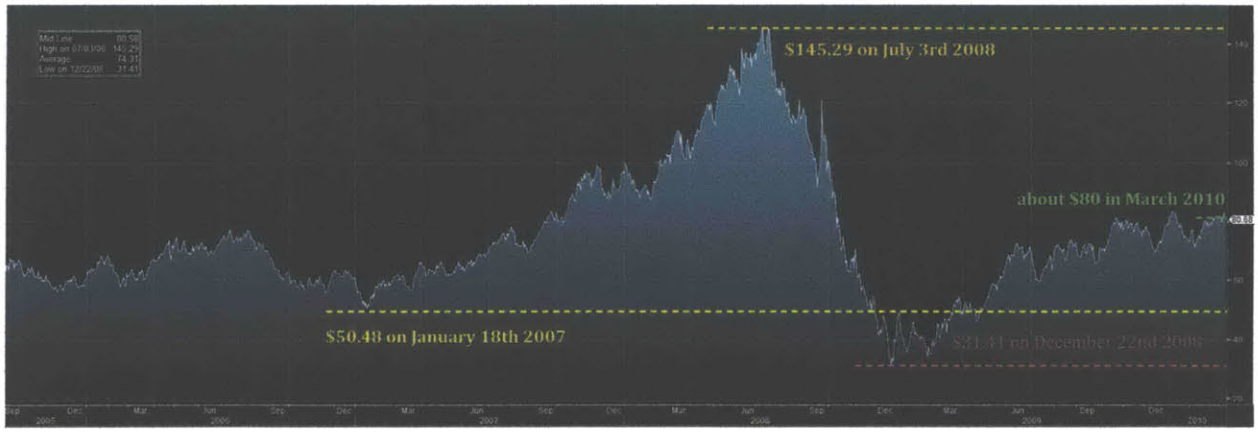
The idea of this thesis topic went to me in spring 2008 whilst I was still considering undertaking MBA studies. After more than a decade spent developing internal combustion engines and therefore burning a lot of oil, I have eventually developed a severe allergy to hydrocarbons and solvents following over-exposure to these chemicals. After a long and steady period around $20/bbl (1 barrel = 42 US gallons = 158.98 liters) in the late 1980's and throughout the 1990's (at the only exception of a peak around $40/bbl in late 1990/early 1991 following the invasion of Kuwait by Iraqi troops and the subsequent first Gulf War), oil price started to rise steadily but smoothly in the first half of the 00's (figure 1). From early 2007 ($50/bbl in January 2007) the rise started to get steeper and steeper. In spring 2008, the rise accelerated again and skyrocketed at nearly $150/bbl in early July 2008 (figure 2). At that time, the explanation given by the economists were threefold. Price were high because demand was high (thanks to the emergence of China and India), supply was stagnating (Peak Oil not far away, if not already reached) and there was some suspicion of excessive speculation on the markets as well.

Figure 1



Bloomberg West Texas Intermediate (WTI) Cushing Crude Oil Spot Price
Weekly 5/20/1983 – 3/19/2010

Figure 2



Bloomberg West Texas Intermediate (WTI) Cushing Crude Oil Spot Price
Daily 10/3/2005 – 3/19/2010

These experts explained in the news with a lot of confidence that this was the end of the cheap oil era and that we should prepare ourselves to contemplate the price of oil to carry on rising all the way up to $200/bbl if not $250/bbl in the months to come... Less than 6 months after, the oil price had sunk down to $30/bbl ($31/bbl on December 22nd 2008)! Of course, this massive drop coincides with the biggest financial crisis since the Great Depression of the 30's and as per today (March 2010) oil price is back in the region of $80/bbl.

Although I do appreciate that like any other commodity, oil price is mainly driven by supply and demand, the mechanical engineer I was at that time struggled to understand how such precious commodity can see its price fluctuate so much and so quickly. Literally, we are talking of ×3 in 18 months and ÷5 in 6 months! The finance student I now am would like to dig further and to understand if such a rollercoaster was predictable.

During spring 2009, still right in the middle of the financial crisis, I've had the opportunity to ask to Mr. Jean Cyril Spinetta, CEO of Air France, how airlines which are very much exposed to oil price risk do to hedge against such risk. His answer was that after having

been more than €1.0bn in the money at the beginning of the financial crisis, Air France eventually lost so much that they have decided to stop hedging. He added that Air France now focus on reducing their exposure to oil price investing on more fuel efficient aircrafts and jet-engines. At a time when the population starts to be more sensitive to environmental issues like Global Warming, when new technologies like video-conference make corporations reconsider the relevance of many business trips, and when demand for oil will soon exceed supply, can an airline afford not to hedge?

Originally, the idea was to split this thesis in three parts. Part I was supposed to review how oil prices have evolved in the past and recently in order to try to predict them in the future. Part II was supposed to review the financial tools available to businesses exposed to oil price risk and how they should use them in order to hedge this risk or not. Part III was supposed to depict modern and future oil-related financial engineering tools applied to risk management (ETFs in particular) and what they can bring to the different stake-holders (corporations, financial intermediaries, and speculators). Eventually, due to tight time constraints, I have decided to focus and to develop Part I only but more in details than originally planned.

It is understood that this topic is already widely covered by many experts including members of MIT faculty. This thesis doesn't have the pretention to be a fundamental research PhD level thesis. This work must be more considered as a wrap-up and description of existing material rather than fundamental research.

In his Pulitzer Prize winning book *The Prize: The Epic Quest for Oil, Money and Power*, Daniel Yergin said **"Oil is 10% business and 90% politics"**. Daniel Yergin is also the co-founder and Chairman of Cambridge Energy Research Associates, one of the world's leading consulting and research firms in its field.

What is Oil?

Petroleum oil is the result of a lengthy and rare geological and chemical process. Whilst heated and subject to extremely high pressures, ancient organic material is chemically transformed into agglomerates and chains of atoms of carbon and hydrogen. It is believed that organic material at the origin of petroleum oil is seaweeds that were planted in the bottom of the lakes and in the ocean floors during warming periods of the Earth some 30 to 300 million years ago. These dead plants (named kerogen) piled up in submarine sediments and have later been compressed by the movement of Earth's crust some 7000 ft to 15000 ft deep. Temperature and high pressures withstood at these depths are the perfect conditions for these kerogen-based sediments to transform into hydrocarbons saturated sedimentary rocks.

The term "petroleum oil" comes from the Latin "petroleum" which means literally "rocky oil".

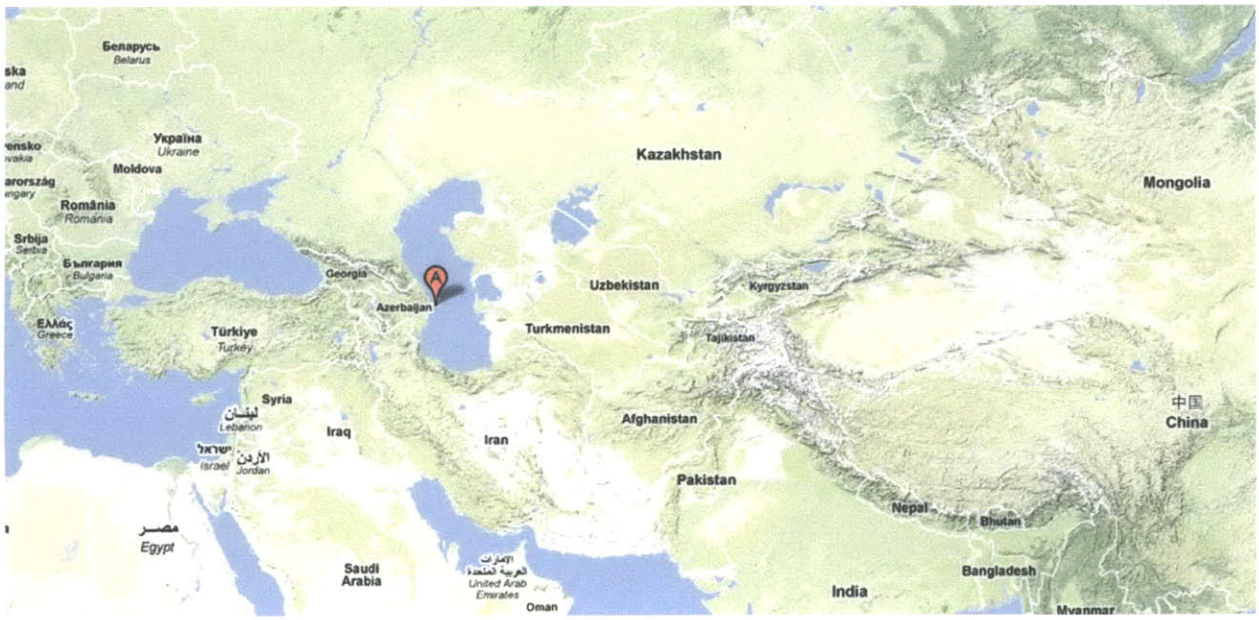
History of Oil

Baku

As far as it can be remembered, petroleum oil has first been spotted in the region of Baku (*figure 3*) nowadays located in the independent Republic of Azerbaijan. Azerbaijan is a Middle-Eastern country located in the Caucasus region of Eurasia, at the crossroads of Eastern Europe and Western Asia. Surrounded by Russia, Georgia, Armenia and Iran, its eastern natural border is the Caspian Sea. Formerly part of Persia (ex-Iran), Azerbaijan has been annexed to the Russian Empire in 1813. This ex-Soviet Republic is independent since 1991 and the collapse of the Soviet Union.

In its travels tales of the end of the XIIIth century, Marco Polo (Venetian Merchant) mentioned that in the region of Baku oil sweats out of rocks and that the ground is impregnated with a dark liquid that denizens use as heating oil, lubricant and medicine.

Figure 3



Excerpt from Google Maps – Flag "A" in Baku, Azerbaijan

At the end of the XIXth century, the Tsarist regime sold the first concessions to the highest bidders for up to $1m the lot for piece of land that were nearly worthless only some month before. There was no real need for savvy geological knowledge in order to find the oilfields as the local populations themselves used to dig manually for centuries! The first oil wells have been installed in 1875 at Bibi Eibat in the South suburbs of Baku. A little bit like the gold rush started in California in 1849, an oil rush started around Baku and it is at this time that the Nobel brothers built their wealth.

Since the pioneer times, Baku holds a strategic position in the region. German army has tried to get hold of the oil wells in two occasions without any success during WWI and WWII. It is believed that the shortage of oil played a key role in the failure of the Nazi army to invade Russia during WWII. Later, Stalin (born in nearby Georgia) sent the Soviet troops to occupy Iranian Azerbaijan because he considered that Baku which held a strategic position for the oil supply of the Soviet Union that need to be rebuilt after WWII was too close to the Iranian border and its Western interests. The United States (Exxon and Gulf) and the United Kingdom (British Petroleum) which both held considerable interest in the region managed to convince Soviet Union to back-off without entering into another military conflict.

Nowadays, even if oil production is fading away, British Petroleum is still present in the region and holds a third of the shares of the Baku-Tbilisi-Ceyhan pipeline. The 1,100 mile long pipeline which construction cost $3.6 billion links the Caspian Sea (Baku, Azerbaijan) to the Mediterranean Sea (Ceyhan, Turkey) going through Georgia.

On another topic, it is to be noticed that during the several decades under the management of the Soviet Union, the protection of the environment was not a priority for the regime at that time. Today, the region of Baku and the Caspian Sea are known to be extremely polluted.

Pennsylvania

Oil has first been discovered on the American soil by Edwin Laurentine Drake (also known as "Colonel" Drake although he has never been an officer of the US army!) in 1859.

A group of investors who believed in the future of oil and its potential applications had incorporated Seneca Oil Company and had purchased a concession in Titusville in the North West of Pennsylvania, next to the Canadian border (*Figure 6*). It is to be noticed that the 4-stroke internal combustion engine was yet to be invented (Patented by Alphonse Beau de Rochas in 1861) and the first internal combustion engine-powered automobiles were yet to be marketed (around 1885 by Daimler and Benz).

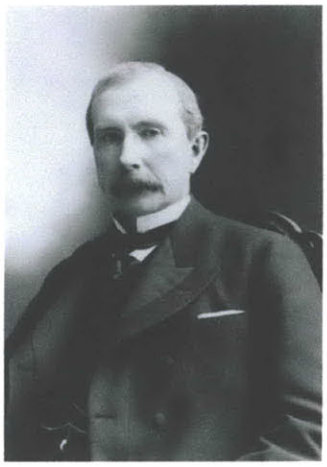
Edwin Drake who lost his job as train conductor due to poor health got hired by Seneca Oil Company in order to explore their concession in Titusville. Drake who believed in the project had been trained earlier on as a driller in France.

First drillings started in Spring 1858 but had to stop during winter due to severe weather conditions. Drillings started again in Spring 1859 but still without any success. Due to the financial losses, Seneca Oil Company sent to "Colonel" Drake the order to stop drilling late in August. Before the order arrived, Drake eventually found oil in the evening of August 29th 1859 from a depth of only 70ft.

Figure 4

Edwin Laurentine Drake

Figure 5

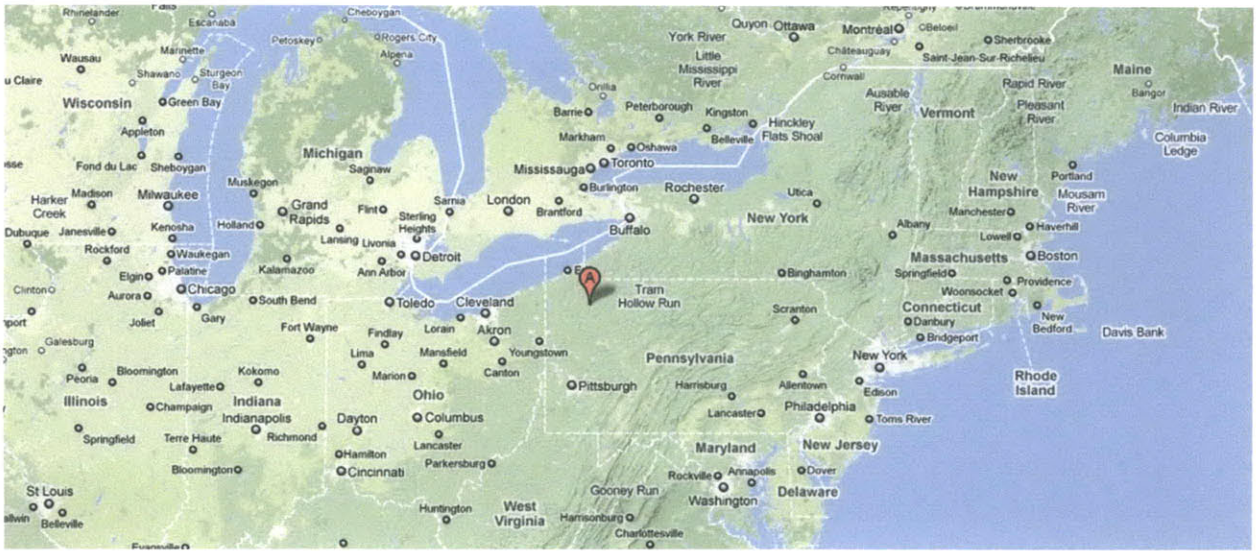


John D. Rockefeller

Figure 6

Benz Patent Motorwagen 1885

Figure 7



Excerpt from Google Maps – Flag "A" in Titusville, Pennsylvania

Following the discovery of this first oilfield in Pennsylvania, oil price skyrocketed up to $20/bbl in 1860. Only a year after, mainly due to the lack of applications at that time (still no automobiles powered by internal combustion engines) oil price sunk down to $0.10/bbl in 1861 and even lower up to a point that oil was cheaper than water! So, we can see that the high volatility of oil price is not a new phenomenon.

Standard Oil Company

Some years after, John D. Rockefeller who previously was an accountant founded Standard Oil of Ohio in 1870. He built his soon to be Oil Empire focusing on oil refining and transportation leaving the much riskier activity of prospection and welling to many independent businessmen. Standard Oil which quickly dominated the World's oil market later made John D. Rockefeller the richest man on Earth. Rockefeller contemplated the crude oil producers and the oil refiners digging their own graves by entering a breathless competition which drove into overproduction and the collapse of oil price at the time

where potential supply was way greater than demand. The following quote from Rockefeller summarizes the frenzied competition at that time and already illustrates his sense of business: "The brave people, if they had produced less oil than they wanted to, they would have been able to take the maximum out of it; if they had produced less oil than demand, no combination on Earth could have made this phenomenon to fail". It is quite cynical to notice that "Colonel" Drake was amongst the victims of this over-production. He was laid-off in 1864 and died poor six years later whilst Rockefeller became the richest man on Earth.

Standard Oil dominated the Oil Industry for 51 years up to 1911 when the US Supreme Court decided to dismantle it into separated entities thanks to anti-trust laws. As a matter of fact, Standard Oil held 90% of US oil refining capacity in 1880 and still more than two third when the breakup happened in 1911. Standard Oil therefore broke up into seven companies supposed to be independent the one to the other. Standard Oil of New Jersey, the biggest one remained under the direct control of the Rockefeller family. It later became Exxon still at present the largest private oil company in the world. Standard Oil of New York became Mobil which, quite ironically merged back with Exxon in 1999 almost a century after the original spin-off. Standard Oil of California became Chevron. Standard Oil of Indiana became Amoco (merged with BP in 1998). Despite the breakup, the seven "independent" companies avoid commercial war and seal secret deals in order to keep the oil price as high as possible. Hence, these companies are still flourishing but remain focused on mainland USA. Royal Dutch Shell, its big competitor, has a diversified presence all over the planet. As earlier as the 1920's, Shell owns oilfields in the USA, Mexico, Venezuela, Trinidad and Tobacco, Dutch Indies (ex-Indonesia), Ceylon (ex-Sri Lanka), Romania, Egypt, Malaysia, Thailand, China, Philippines, Burma, Colombia and Azerbaijan.

Figure 8

Standard Oil logo

Figure 9

Amoco logo

Figure 10

Mobil logo

Figure 11

Chevron logo

Anglo-Persian Oil Company

The Briton William Knox d'Arcy obtained from the shah of Persia (ex-Iran) a concession equivalent to five sixth of the Persian territory (larger than the State of Texas) in 1901. Thanks to the determination of G.B. Reynolds (driller), some oilfields were found and the Anglo-Persian Oil Company which later became British Petroleum (BP) was founded in 1908. For the first time, the oil industry started to become a strategic issue. At that time, the British Government transferred some regiments of the British Indian Army to the region in order to monitor and protect the Persian oilfields. In July 17th 1913, Winston Churchill declared at the Parliament: "Britain must become owner of Anglo-Iranian Company, or at least take control of at least a proportion of the crude oil we need". One year later, he proposed a project following which Britain would invest £2.2m for a 51% stake of the company's equity. British Petroleum became a sizeable rival of Standard Oil and Royal Dutch Shell (Anglo-Dutch).

Development of the Automobile Industry

In 1900, there were only 8,000 automobiles and 105 miles of sealed roads in the US.

In 1908, Henry Ford launched the famous "Model T" which was the first affordable car ever mass produced. Retail price was $850 at launch (equivalent to $20,500 of today's USD) and dropped below $300 (equivalent to $3,250 of today's USD) in the 1920's thanks to productivity gains. When production was stopped in 1927, more than 15 million Model Ts had been produced which still remains a hit by today's standards!

In 1911, there were 619,000 automobiles in the world.

In 1914, there were 2 million automobiles in the world. That year, world oil consumption was only of 6 tons per year which is equivalent to 0.12 million bbl/day (vs. more than 80 million bbl/day nowadays!) what is to say way below coal consumption at that time but it was already a critical issue because politicians, militaries and business men had already understood how important it would be for defense (ships, aircrafts, tanks) and the future economic development.

In 1920, one American out of ten owns a car and the other nine save money to buy one.

In 1924, there were 18 million automobiles in the world including 16 million in the US (89%). That year, oil consumption in the US was higher than what it will be in Western Europe in 1960!

In 1929, 78% of the automobiles in the World are still on the US soil.

In 1945, there were 26 million cars in the US.

In 1950, there were 40 million cars in the US.

Figure 12

Ford Motor Company Assembly Line

Figure 13

1910 - Ford Model T

<u>*World War I*</u>

The rising and strategic importance of oil has been highlighted by WWI. William II, Emperor of Prussia wanted to compete with Britain with respect to access to oil and sought access to the oilfields of Mesopotamia (ex-Iraq). He therefore launched the construction of a railway linking Berlin to Basra through Constantinople (ex-Istanbul) and Baghdad (both located in the Ottoman Empire at that time). Deutsche Bank mainly financed the project. The railway was also a way for Germany to get access to the Eastern part of its Empire, bypassing Suez Canal which was under the control of the British at that time.

It is believed that disputes over the Berlin-Baghdad railway were amongst the contributing factor to the onset of the first world conflict.

For the first time, oil was key for the transportation of the troops to the battle-fields. It was also the first use of tanks at a large scale and also the first air combats.

On September 6th 1914, General Gallieni (military Governor of Paris) commandeered 600 taxis in order to move 5,000 French soldiers to the battle-field in the North-East of Paris in order to contain German troops. The cars were mainly Renaults AG1 (top speed of 25km/h = 15mph) and the episode is remembered as "Les Taxis de la Marne".

During the conflict, members of the "Triple Entente" (United Kingdom, Russia and France) mainly relied on the US which controled about two thirds of the world production (266 million bbl in 1914, 335 million bbl in 1917). 80% of the oil consumed by the Allied Forces during the conflict came from the US whilst the Middle-East and especially Iran under the control of the British only provided 5% of the supply. Nearly a quarter of this oil supply from the US came from Standard Oil of New Jersey!

Figure 14

Berlin-Baghdad Railway

Figure 15

Taxis de la Marne

In addition, the emergence of the Bolshevik Revolution in October 1917 cut access to the Russian oilfields (located in the region of Baku) where 15% of the world production came from. US provides oil to its Allies in Europe thanks to oil tankers but many of them are sunk by German submarines (the U-boats).

Oil supply to the battle fields really became key for the first time during WWI. On December 15th 1917, Georges Clemenceau (new appointed President of France) sent a telegraph to President Wilson in which he says: "any lack of fuel would cause the sudden freeze of our armies and could drive the Allies to concede to an unacceptable peace. If the Allies don't want to lose the war, fighting France, at the time of the supreme Germanic shock, needs fuel, as much as blood in the future battles". One year later, in his speech following the cease-fire, Clemenceau added: "From now on, for the nations and for the peoples, a drop of oil is worth a drop of blood".

The end of WWI is an opportunity for the ex-Allies to make strategic "acquisitions". Before the war, the Turkish Petroleum Company which belonged to the Anglo-Iranian (ex-BP: 50%), Royal Dutch Shell (25%) and Deutsch Bank (25%) owned the Iraqi oilfields. In 1918, the Ottoman Empire which was allied to Germany has been dismantled and the share of Deutsch Bank got "acquired" by the Compagnie Francaise des Petroles (ex-Total).

Soon after, the British Authorities denied access to the Iraqi soil to Standard Oil of New Jersey and Mobil which were willing to prospect. In answer to this, Royal Dutch Shell got excluded from auctions to concessions in the USA for a while. Some diplomats believe that a war about the matter between USA and UK got avoided at last minute. Eventually, a business agreement was found to solve the issue. Turkish Petroleum Company was renamed Iraq Petroleum and shared between Anglo-Iranian (ex-BP), Royal Dutch Shell, Compagnie Francaise des Petroles (ex-Total) which each got 23.7% and Standard Oil of New Jersey (ex-Exxon) and Standard Oil of New York (ex-Mobil) which each got 11.87%. Calouste Gulbenkian who put the deal together got the remaining 5%, probably the biggest commission fee of the industry of all times! He got remembered in the industry by his nickname: Mr Five Percent...

Birth of an International Oil Cartel

At the dawn of the second world conflict, two third of the oil world production still comes from the US but the thousands of independent oil producers put pressure in order to keep production price high. Therefore, big US oil companies have an incentive to look for cheaper oilfields. Iran and Iraq with their immense oilfields of high quality with low production costs look very attractive. Since the dismantlement of the Turkish Petroleum Company, Exxon and Mobil have joined British Petroleum and Shell in the region. In order to avoid a commercial war driving to overproduction and subsequent drop of the oil price, these new "four sisters" agreed to work alongside each other in order to keep oil price high.

Red-line Agreement

The main share-holders of Iraq Petroleum Company (Anglo-Iranian, Royal Dutch Shell, Compagnie Française des Pétroles, Standard Oil of New Jersey and Standard Oil of New York) met in Ostend (Belgium) in June 1928. They decided to enter into a non-aggression gentlemen's agreement. They decided that any oilfield found by any party in the territory of the old Ottoman Empire would have to be shared between one another. The Ottoman Empire having had its borders moved a lot throughout the history, it was eventually decided that the region in question in the agreement would be the Ottoman Empire as it was in 1914, at the beginning of WWI. Calouste Gulbenkian (already mentionned above as "Mr. Five Percent") who was native of the region (he was Armenian) drawed himself the borders on a map in order to determine the region in question with a red pencil. Therefore, the secret agreement got remembered as the "Red-Line Agreement". Whilst Barain, Qatar, Arab Emirates and Saudi Arabia are within the limits of the red line, Kuwait is out (*figure 16*).

Figure 16

Limits of the "Red Line Agreement" (ex-Ottoman Empire)

sealed in June 1928 in Ostend (Belgium)

Achnacarry Agreement

The members of the "Red Line Agreement" met again in August 1928 in the Castle of Achnacarry (Scotland) which is the property of the Dutch Henry Deterding (founder and President of Royal Dutch Shell). They got joined by Andrew William Mellon, banker and industrialist but also the main share-holder of Gulf Oil Corporation. Eventually, a new secret agreement is sealed (the so-called *Achnacarry Agreement*) in order to eliminate competition among the parties in presence. The companies want to avoid over-production which would drive the prices down. They also divide the world markets and decide to freeze them on an "as is" basis taking their respective 1928 market shares as a reference for the deal. That is why the *Achnacarry Agreement* is also known as the *"As Is"* Agreement. Standard Oil of California (ex-Chevron) and Texaco joined the cartel soon after. Of course, this agreement was kept secret because illegal with respect to US free trade laws. The Achnacarry Agreement eventually got unveiled by the Federal Trade Commission 24 years later, in 1952.

Even though US territory is not included in the Achnacarry Agreement, the members of the cartel restricted production in order to guarantee high prices. They also make sure that worldwide, oil price is in line with the price of oil from Texas and Gulf of Mexico which is the most expensive. They also add on top of that shipping price as if oil came from that region. This "gentlemen agreement" is especially profitable for British Oil companies selling oil from the Persian Gulf (which is cheap to produce) to European countries (because the real shipping distance is way shorter, so cheaper as well in comparison with what is charged). These agreements allow the members of the cartel to maximize their profits whilst avoiding competition and some of them were particularly cynical. During WWII, BP (controlled at 51% by the State of United Kingdom at that time) charged the fuel delivered to British and American warships moored in the harbor of Abadan in Iran at the price of the Texan fuel surcharged by the fictitious shipment cost from Texas to Iran whereas, in reality, the fuel came from local oilfields!

At the onset of WWII, the "seven sisters" (Exxon, Shell, Texaco, Mobil, BP, Chevron and Gulf) were in a quasi-monopolistic situation. They controlled most of the oil world market and this situation would last up to the first oil shock in the 1970's.

World War II

It is quite stunning to realize how some of the most powerful businessmen of the oil industry and industrialists at that time were close to the Nazi regime. Some of them by conviction and some others by pure cynicism. They probably believed that Hitler would be the best barrier against communism that was putting their interests in jeopardy.

The Dutch Henri Deterding, founder and Chairman of Royal Dutch Shell, also called the "Napoleon of Oil" and probably the biggest rival of John D. Rockefeller was so close to the Nazis that he eventually had to leave the company he founded four decades before. He eventually died in February 1939 in St Moritz in Switzerland just before the second worldwide conflict started. Hitler and Goering sent flowers to his funeral.

Walter C. Teagle was the successor of John D. Rockefeller at the head of Standard Oil of New Jersey which later became Exxon. He signed a business agreement with IG Farben in 1926. IG Farben was a giant German Chemical group of sinister memory for having developed the "mustard gas" used as a chemical weapon during WWI and later the "Zyklon B" used in the gas chambers of extermination camps during the holocaust during WWII. It is to be noticed that Chase Bank which belonged to the Rockefeller family held shares of IG Farben. In the mid-1930's whereas the Nazi regime was already in control in Germany, Standard Oil gave away the patent of tetra-ethyl lead to IG Farben. Tetra-ethyl lead is an anti-detonation additive particularly important for the blending of aviation fuel and synthetic fuel. Later, Standard Oil and General Motors (lead by Alfred P. Sloan at that time) made an alliance with IG Farben to build tetra-ethyl lead chemical factories in Germany. Albert Speer who was Minister of Armaments and War Production of the Third Reich admitted during the Nurnberg Trial (during which he was sentenced to 20 years) how precious synthetic oil

(which represented nearly 50% of Germany's oil supply during WWII) had been for the Blitzkrieg (lightening war) against Poland and France.

Sanctioned for its war crimes, IG Farben got dismantled after WWII into Bayer, Hoechst and BASF which are still amongst today's biggest chemical companies in the world.

Standard Oil got charged in 1941 for having provided top industrial secrets to IG Farben and eventually the case got settled off the court in exchange of a $50,000 fine which was a rather meager sentence given the huge profits acquired thanks to the collaboration with the German firm. Following the scandal, Walter C. Teagle eventually had to retire from Standard Oil.

Beside these scandals, oil has once again played a key strategic role in the victory of the Allies or some would rather say, in the defeat of the Nazi regime. Germany knew from the start that they would be short of oil and that's why they have put so much effort into developing synthetic oil (already mentioned above). That's also why they have preferred applying blitzkrieg (lightening war) strategy because less oil hungry. Despite its non-aggression pact sealed with Stalin, Hitler eventually decided to invade the Soviet Union mainly in order to get access to its Caucasian oilfields which would also have had the side effect of choking oil supply to Russia. Stalin who was too much aware of the strategic importance of these oilfields had already posted many troops in the region and the German army eventually failed not so far away from Baku. German army also relied on the back-up of Rommel troops who never arrived from Africa because short of oil.

On the Pacific front, USA and UK decided an oil embargo towards Japan in 1941 which might have been a contributing factor for the attack against Pearl Harbor.

Despite their oilfields in the Middle-East, Britain mainly relied on American oil and like already occurred during WWI even more sophisticated U-boats (German submarines) sank many of the oil tankers coming from the US.

Hence, if some short cuts with respect to ethics have definitely been taken by some of the giants of the oil industry, it is to be noticed that US oil has, like it did during WWI, played a

key role in the victory of the Allies during WWII. More than two thirds of the oil supply during the conflict actually came from the US.

Suez Crisis

Suez Canal is a 100 miles long canal joining Mediterranean Sea to the Red Sea. It is located in Egypt between Sinai Peninsula and mainland Africa. It holds a strategic importance in so that it allows oil from the Persian Gulf to be shipped straight to Southern Europe via the Mediterranean Sea avoiding a long detour around Africa and the Cape of Good Hope. It also gives access to Northern Europe and America through the Gibraltar Straight.

From Jeddah in Saudi Arabia (Red Sea) to Athens in Greece (Mediterranean Sea), the Suez Canal allows an 11,450 miles long shortcut (18,300km – 9,900 nautical miles). From Ras Tanura in Saudi Arabia (Persian Gulf) to Rotterdam in the Netherlands, the Suez Canal saves 5,500 miles (8,800km – 4,700 nautical miles). From Singapore to New York, 2,750 miles are saved (4,400km – 2,400 nautical miles).

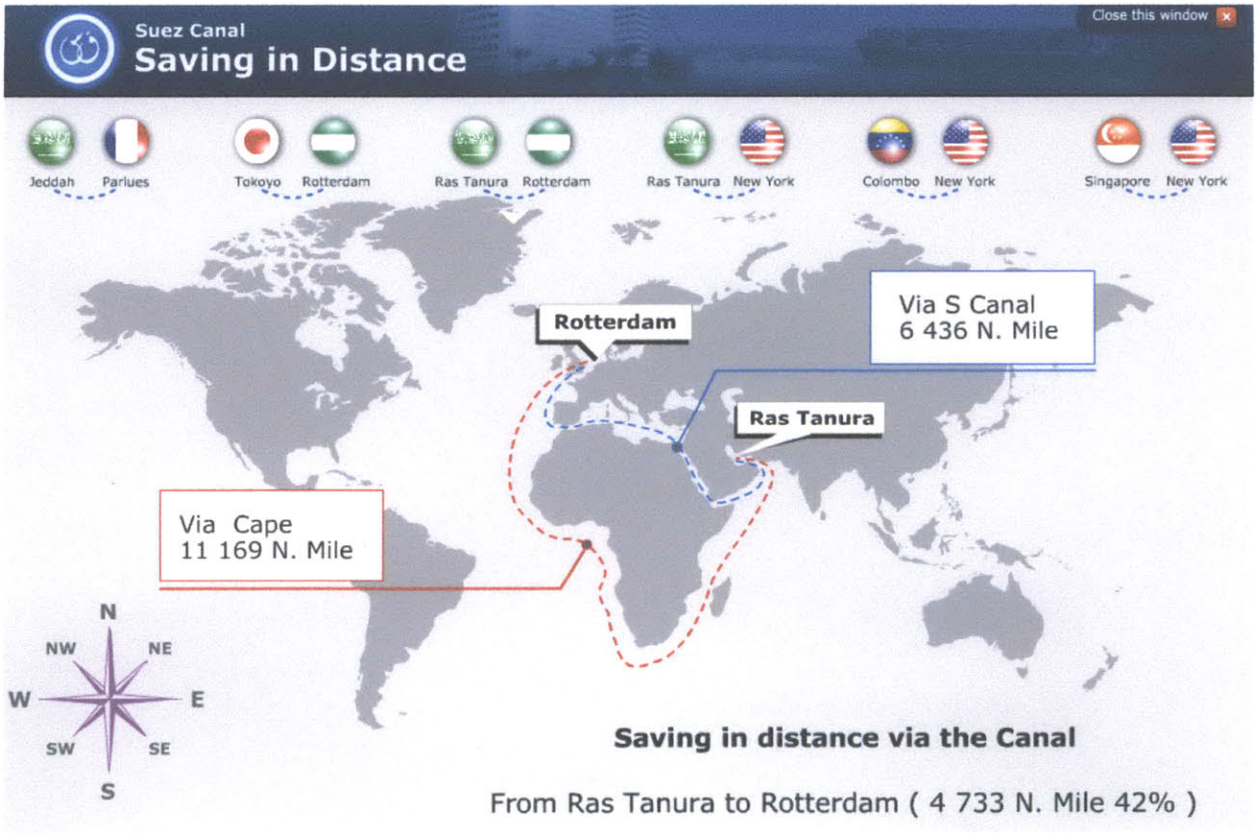
Figure 17

Excerpt from Google Maps

Suez Canal (red ellipse) - Gibraltar Straight (blue ellipse) - Aswan Dam (flag A)

Post WWII, two third of the oil at destination to Europe was shipped through the Suez Canal. It was built by a French Company (Compagnie Universelle du Canal Maritime de Suez) in the ninetieth century and opened to navigation in 1869. The region was ever since under the control of the British. Post WWII, USA and UK originally promised to help Egypt finance ($500 million) and build Aswan Dam in order to irrigate the South of the country. Following later connections of Egypt towards the Soviet Union, US and UK eventually backed-off their original offer. Consequently, Gamal Abdel Nasser (President of Egypt) decided to nationalize Compagnie Universelle du Canal Maritime de Suez on July 26th 1956 in order to finance the Aswan Dam with the proceeds of the canal. This was the trigger of a political military crisis which involved Britain, France and Israel against Egyptian troops. In October 29th 1956 Israel invaded Sinai Peninsula. On the day after, UK and France decided to occupy Suez Canal area.

Figure 18



5,500 miles shortcut allowed by the Suez Canal from the Persian gulf to Northern Europe

As a result of the crisis, Suez Canal was closed to commercial navigation for six months and re-opened April 1957. This obliged oil tankers to take the long Cape of Good Hope detour. Oil companies took this opportunity to rise the price of crude oil delivered to Europe of $2 per ton. They did likewise for crude oil coming from Texas and the Gulf of Mexico delivered to the US domestic market! This cost $1.25 billion to US customers and $500 million to European customers. Suez crisis allowed Exxon to boost its profits of an extra $100 million. During the first semester of 1957, Exxon saw its profit rising of 16%, Texaco of 24% and Gulf of 30%.

Most importantly, this episode saw the diplomatic influence of Britain in the Middle-East seriously weakened at the benefit of the US. In addition, the nationalization of the Suez Canal by Gamal Abdel Nasser announced the emergence of the pan-Arabism political movement. Other political leaders of the region frustrated at the idea to see little revenue of the proceeds of the oil coming from their oilfields decided soon after to nationalize the oil companies of their countries. This was the case in Iraq, Algeria and Libya.

O.P.E.C: Organization of the Petroleum Exporting Countries

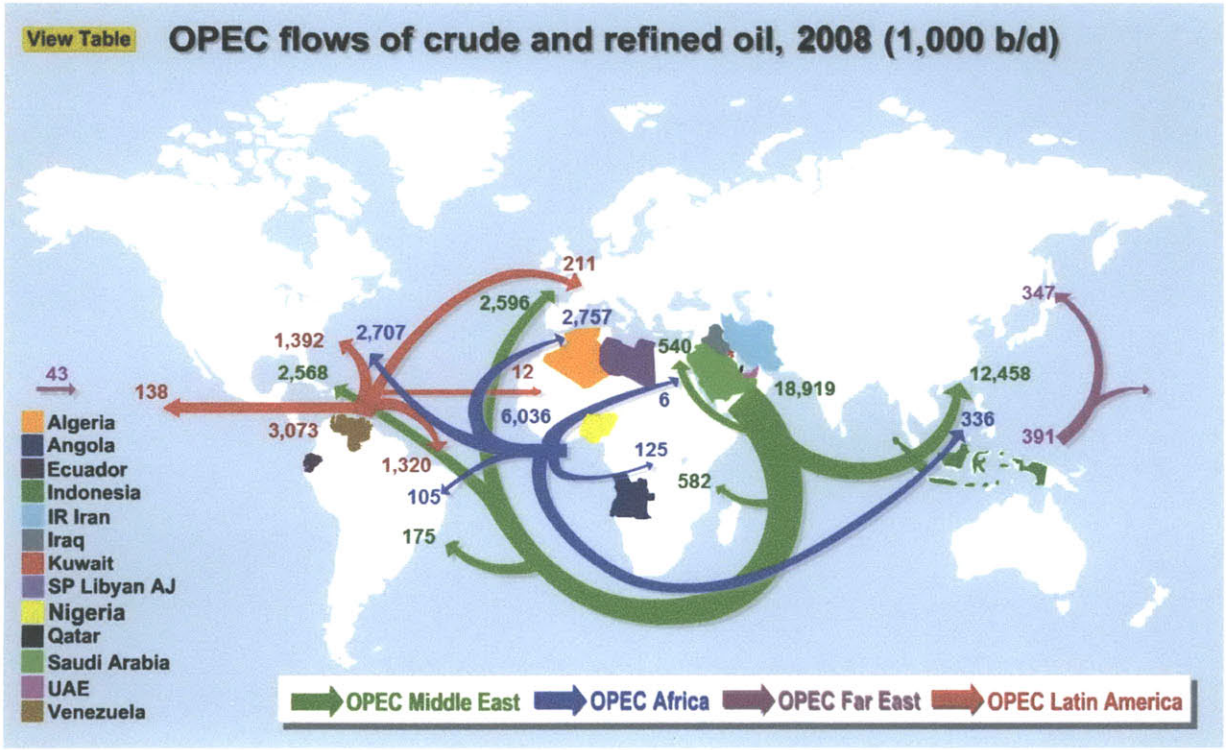
In need for foreign currencies, the Soviet Union started to export oil massively in the 1950's. This drove to over-production and therefore to the drop of oil prices. At that time, whereas the profits between oil producing countries and oil companies was supposed to be on a "50%/50%" basis, it was current practice for the big oil companies to minimize upstream prices in order to maximize downstream profits which was at the expense of the fees paid to the producing countries as these fees are based on the price of crude oil charged to the importing companies.

In July 1960, Exxon decided to artificially drop the price of crude oil of $0.14/bbl without prior notice to producing countries. Soon after, Royal Dutch Shell, British Petroleum, Mobil and Amoco took the same decision. This decision had the immediate effect of dropping the

fees paid to producing countries of 7.5%. It is to be noticed that these fees were often the main, if not the only, source of income of these countries. In answer to what they considered to be a new provocation of the "seven sisters", Iran, Iraq, Kuwait, Saudi Arabia and Venezuela created OPEC at the Baghdad Conference on September 10th 1960. The five founding countries which represented at that time 90% of oil exports in the world believed they would be stronger if allied together in order to negotiate with the "seven sisters". Strangely enough, the event which later proved to be a major turn in the industry got initially little attention in the Western media. Qatar joined the organization in 1961, Indonesia and Libya in 1962, United Arab Emirates in 1967, Algeria in 1969, Nigeria in 1971, Ecuador in 1973, Gabon in 1975 and Angola in 2007. OPEC had its headquarters based in Geneva in the first five years of its existence and was then moved to Vienna in Austria in 1965.

Whereas USA had been the biggest oil producing since the beginning of the industry in the 1860's, Middle-Eastern countries outpaced oil produced in the USA in 1965.

Figure 19



It is also to be noticed that USA became a net oil importing country in 1948 and therefore has been relying more and more on foreign oil ever since. Its main partner at that time was Saudi Arabia (largest production and reserves in the wolrd) where Saudi ARAMCO (joint-venture between Exxon, Mobil, Texaco and Chevron) had full control of all oil operations on the Arabian peninsula. Due to its strategic importance for the Kingdom, Saudi ARAMCO got nationalized in three steps (25% in 1973 following US support of Israel during Yom Kipur War, 60% in 1974 during the first oil shock and 100% in 1980).

Despite their preliminary intentions, OPEC members were initially too divided to fight against the "oil cartel". Abdullah al-Tariki (Saudi Arabian Minister of Petroleum and Mineral Resources) who was amongst the most vehement against the "seven sisters" even had to quit office in Mars 1962 in an attempt from King Saud and Prince Faycal (worried with the growing influence of the Soviet Union in the region) to keep good diplomatic relationships with the US.

Six-Day War

The Six-Day War, more or less an aftermath of the Suez Crisis already mentioned above, saw Israel opposed to its Arab neighbors Egypt, Syria and Jordan from June 5th to June 10th 1967. This has been the first attempt of OPEC Arab members to impose an oil embargo against the Western Allies of Israel. Anyhow, this embargo is believed to have last less than a week. As a matter of fact, the OPEC Arab members quickly realized the boomerang effect of such measure on their respective national finances which none of them could afford.

Libyan Revolution, preamble to the first oil shock

Located in Northern Africa, bordering the Mediterranean Sea between Egypt and Algeria (its two biggest neighbors) most of Libya's land is barren.

Under the control of the Ottoman Turks, Libya became an Italian colony in 1911. After the defeat of the fascist regime of Mussolini at the end of WWII Libya then became under the administration of the United Nations in 1943 and eventually gained independence in December 1951.

Whereas the first oilfields have only been discovered in Libya in the late 1950's (quite ironically Rommel's troops ran out of oil in the region a decade before) by 1965 Libya was already the 6th largest oil exporting country with its production being equal to 10% of world oil exports. In 1967, its production was of 3 million bbl/day and by 1969 its production even exceeded the one of Saudi Arabian. As per today, Libya still holds a key role in the petroleum industry with a production of 1.9 million bbl/day (19th rank in the world), exports of 1.5 million bbl/day (15th rank in the world) and proved reserves of 44 billion bbl (9th rank in the world).

Figure 20

Excerpt from Google Maps - Flag "A" in Sarir Field,
the largest Oilfield in Libya, previous property of Occidental Petroleum

Libya's oil has many qualities: it is cheap to produce and it is of high quality with low sulfur content. In addition, it holds the strategic advantage to be located close to the European markets where it can be shipped through the Mediterranean Sea without getting through Suez Canal (which got closed again after the Six-Day War mentioned above from 1967 to 1975).

In September 1st 1969, Muammar Abu Minyar al-Qadhafi set-up a military coup against King Idris I and took control of the country. A partisan of the Egyptian President Gamal Abdel Nasser and his pan-Arabism doctrine, Colonel Qadhafi was determined to use oil as a weapon against western nations.

One of Colonel Qadhafi's first decisions was to oust US Air Force from Wheelus Air Base in the North West of the country. Nixon Administration decided not to strike back in a diplomatic attempt to keep US oil interests in the country. This was without counting on Colonel Qadhafi's determination to nationalize all the oil companies present on the Libyan's soil. Eventually, one of Colonel Qadhafi's advisors who feared the power of the "oil cartel" members if allied altogether in a fight against Libya convinced him to pick-up the weakest of the oil companies operating in Libya and to "squeeze" it. It is what happened. Colonel Qadhafi therefore threatened Occidental Petroleum (also known as "Oxy") to be nationalized. Occidental Petroleum was the 8th biggest oil company at that time but held the concession of the biggest Libyan oilfield in the region of Sarir (*Figure 19*). Armand Hammer, owner of Occidental Petroleum, sought assistance to the "seven sisters" but the latter, jealous of Oxy's giant oilfield in Libya, were too happy to let it down. In September 1970, Occidental Petroleum had no choice but to accept an increase of the fee paid to Libya of $0.30 per barrel with an additional rise of $0.02 per barrel and per year for the 5 following years (so, an increase of $0.40 in total). In addition, Occidental Petroleum conceded a rise of income tax paid to the Libyan state from 50% to 58%. A month after (October 1970), whilst world demand for oil started to overtake supply all the other oil companies operating on the Libyan soil had conceded the same conditions. In August 1973, Libya partially nationalized Occidental Petroleum taking control of 51% of its equity.

For the first time of the oil industry, the members of the "oil cartel" had been "squeezed" by an OPEC member. This episode can definitely be considered as a preamble to the first oil shock that occurred three years later.

First Oil Crisis

In the mid-1960's, world oil consumption grew at an unprecedented rate of 7% to 8% per year and eventually exceeded coal consumption for the first time. As already mentioned above, with demand starting to exceed supply, the bargaining power started to change from the side of the oil companies to the side of the oil producing countries.

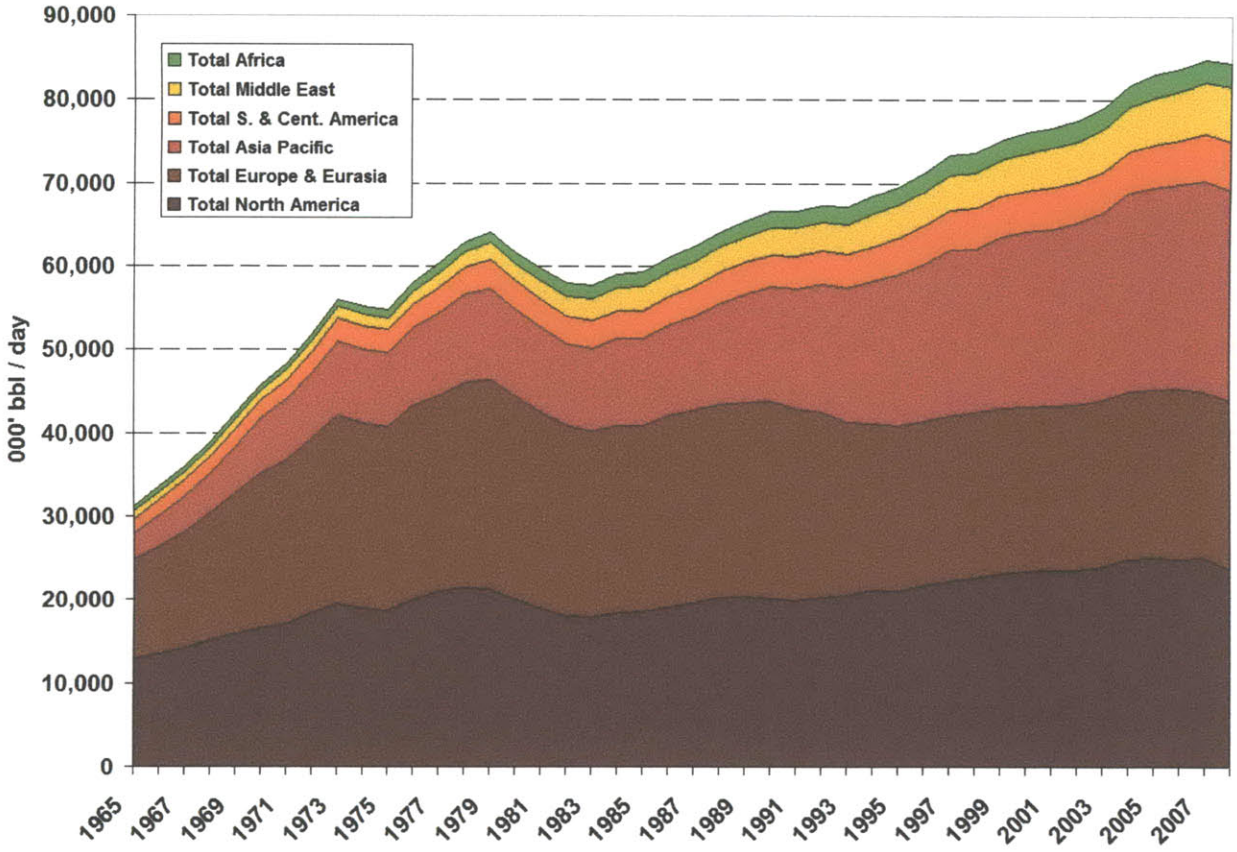
In February 1971, like what happened in Libya six months before, OPEC members obtained from the oil companies an instant rise of the crude oil price of $0.30 per barrel with an additional rise of $0.05 per barrel and per year (so, an increase of $0.50 per barrel by 1975). This deal sealed the end of the "50%/50%" profit-sharing policy between the oil companies and the oil producing countries. The new conditions planed to achieve a new split of the profits of "55%/45%" at the advantage of the OPEC members.

In 1973, Colonel Qadhafi made public his intentions to nationalize all the oil companies operating in Libya. He also threatened to stop oil imports toward the US if Nixon Administration continued to support Israel.

Yom Kippur War

Yom Kippur War saw Israel once again opposed to its Arab neighbors Egypt and Syria from October 6th to October 26th 1973. Egypt was willing to retake possession of the Sinai Peninsula lost during the Six-Day War of 1967. Likewise, Syria was willing to retake possession of Golan Heights lost during the same event.

Figure 20



Evolution of World Crude Oil Consumption from 1965 to 2008

Data from "BP Statistical Review of World Energy" – June 2009

<u>First Oil Crisis</u> (continued)

A new meeting between the oil companies and OPEC members took place in their Vienna headquarters in October 8th 1973, just two days after the start of the Yom Kippur War. Given the circumstances, Arab OPEC members were not really inclined to leniency towards the giant Western oil companies (believed to be on the side of Israel). During the negotiations, Saudi Arabia initially asked for the oil price to double. The "seven sisters" made a counter offer of a 15% rise. Mentioning the Yom Kippur War, OPEC members then threatened of a possible oil embargo.

Eventually, on October 16th, OPEC announced its decision to raise the posted price of crude oil of 70% (from $3.0 to $5.1/bbl).

Soon after, Oil Ministers of OPEC members decided an oil embargo mainly towards the US (but also towards Western Europe and Japan but at a lesser degree) and a reduction of the production of 5% with subsequent increments of 5% until their target price would be achieved.

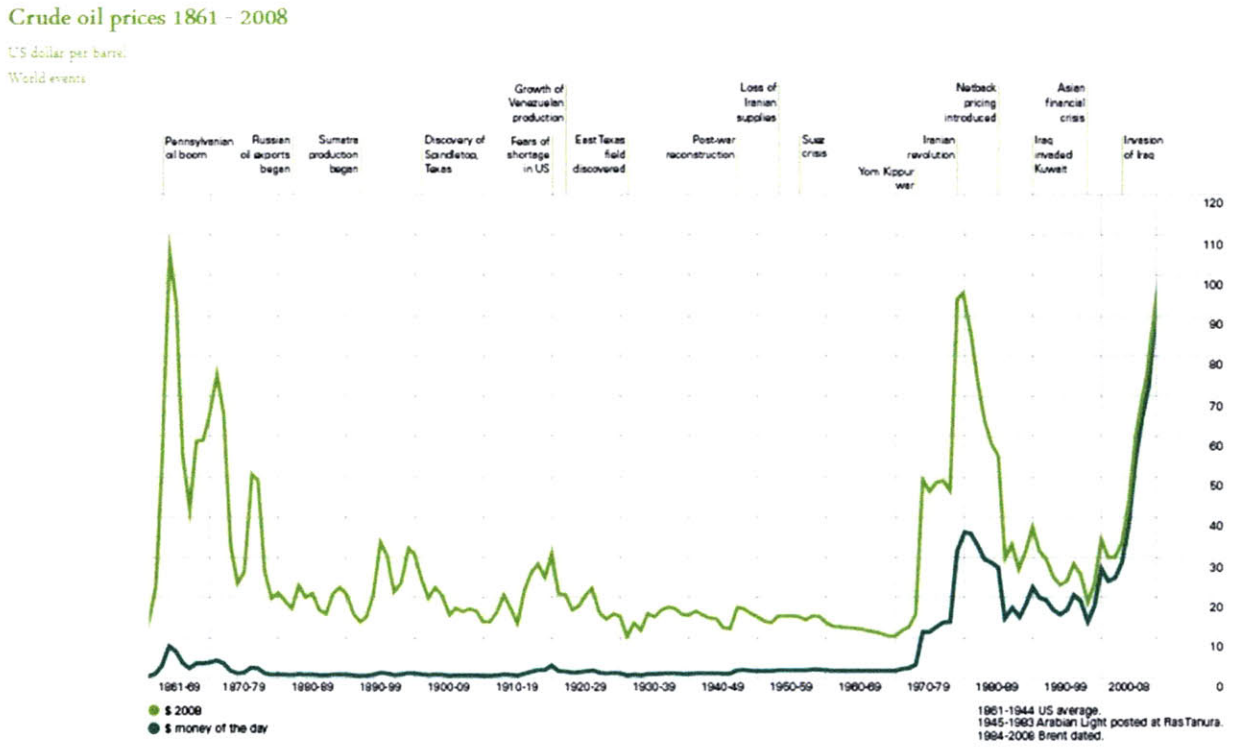
Consequently, oil price skyrocketed. Within the following two months, oil price quadrupled going from $3 to $12 per barrel going beyond all the expectations of the OPEC members.

Apparently, this was a serious setback for the members of the "Oil Cartel" which, thanks to savvy negotiations add managed to keep oil price fairly steady below $2/bbl for nearly a century. In inflation corrected values, oil price had actually dropped in value since the emergence of the industry at the end of the XIXth century.

In reality, some said that this sudden increase of the crude oil price was not such a bad news for some oil companies which were in a financial distress situation. During a conference held in Rome in 1973 prior to the oil crisis David Rockefeller, President of the Chase Manhattan Bank and still holder of a sizeable stake in Exxon's equity, declared that the Oil Industry would need $3 trillion in the years to come in order to finance future explorations. In addition, the spectacular increase of the oil price had the positive side effect for US companies to improve the competitiveness of Texan oil (more expensive to extract than oil from the Middle-East). Another positive side effect of the price increase was the consequent increase of the reserves. As a matter of fact, reserves depend on the price. When oil price increases some oilfields which were initially too expensive to operate become profitable.

Thanks to the drastic rise of the oil price, and despite a slight drop of the consumption (-1.4% in 1974, -0.9% in 1975) the thirty biggest oil companies in the world saw their profits booming of 71% in 1974.

Figure 21



Crude Oil Prices from 1861 to 2008

BP Statistical Review of World Energy – June 2009

Second Oil Crisis

Even if under the influence of Britain and Russia since the XIXth century, unlike its Arab neighbors, Iran never got colonized.

Willing to balance Russian and British influence Reza Khan, Shah of Iran, was suspected of contacts with the Nazi regime during WWII. Therefore, Britain and Russia invaded the country in 1941 and Reza Khan was forced to abdicate in favor of his son Mohammad Reza Pahlavi.

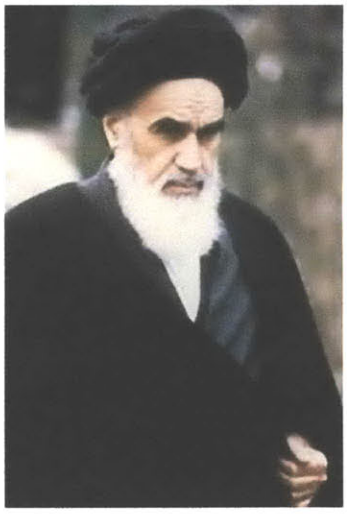
Soon after his election as Prime Minister in 1951, Mohammed Mossadegh nationalized the Anglo-Iranian Oil Company (ex-British Petroleum). Subsequently, Britain embargoed Iranian Oil and sought the support of the US. CIA organized a plot (Operation Ajax) which ultimately saw Mossadegh overthrown in 1953.

With the support of the US, the Shah launched the "White Revolution" in 1963 in order to modernize the country. At this time Ayatollah Khomeini, a Muslim Dignitary, became a vehement critic of the Shah's regime and even went to jail for 18 months which did not really have the effect to temper his protests against the Shah and the US. He ultimately was pushed to exile for more than 14 years in Turkey, Iraq and France.

Figure 22

Mohammad Reza Pahlavi
Shah of Iran (1941-1979)

Figure 23



Ayatollah Khomeini
Supreme Leader of Iran
(1979 – 1989)

The Islamic Revolution started in Iran in 1978 with some protests and strikes against the regime in place and the Shah eventually left the country in January 1979. Then, Ayatollah Khomeini came back to Tehran and the Islamic Republic of Iran was officially declared on April 1st 1979. Then, Ayatollah Khomeini became the Supreme Leader of the country in December 1979.

In November 1979 a group of students who feared that CIA could once again overthrown the new Iranian regime (like what happened to Prime Minister Mossadegh in 1953 following "Operation Ajax") took over the US Embassy. The American hostages eventually got released more than a year after, in January 1981.

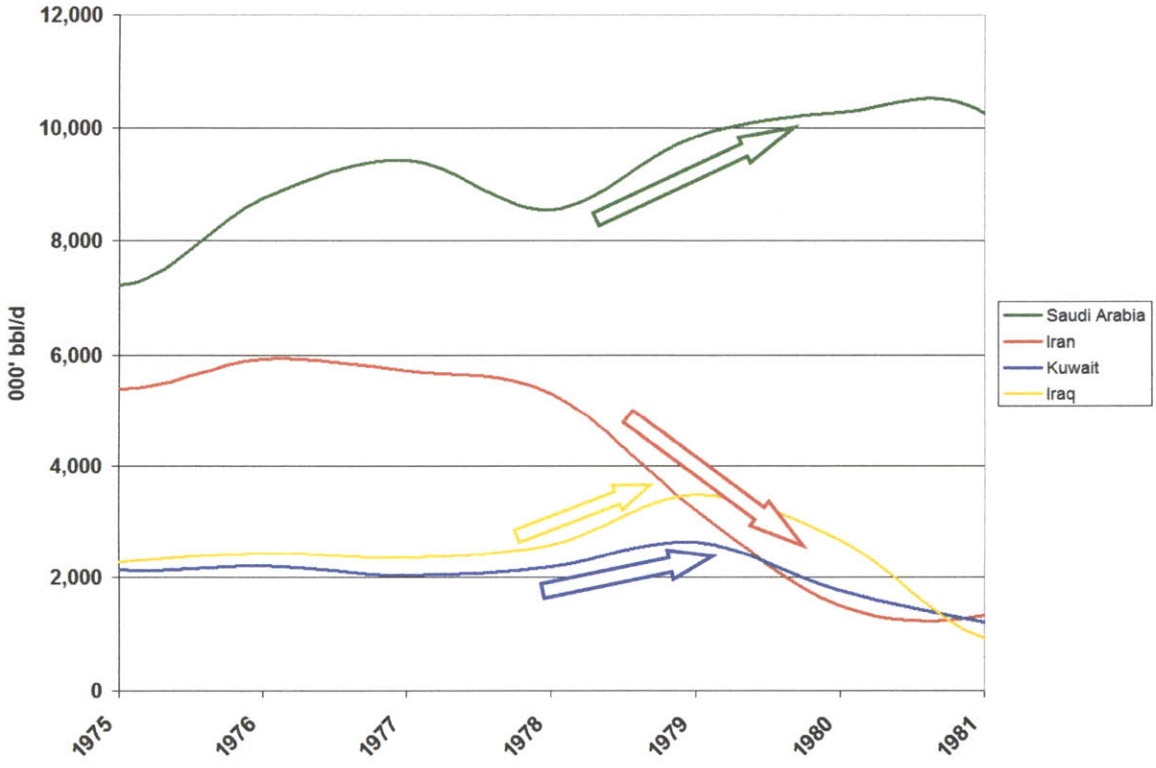
Saddam Hussein (at that time still the ally of the US Administration) was attracted by the South-Western provinces of Iran for their oilfields and access to the Persian Gulf shores (the same reasons pushed him to invade Kuwait a decade later). He decided to launch a strike against Iran in September 1980 in what became the onset of the Iran-Iraq War which lasted for nearly 8 years.

Figure 24

Excerpt from Google Maps centered on Iran and Iraq - Flag "A" in Tehran

The Islamic Revolution triggered the Second Oil Crisis. During the events before the Shah left Iran, the oil production was disrupted due to strikes in the oil industry. When Ayatollah Khomeini took control of the country, oil production and exports resumed but at a lower and less consistent degree. Other OPEC countries (especially Saudi Arabia) increased their own production in order to try to match demand (*Figure 25*). When the Iran-Iraq War aroused, Iran's oil production kept on dropping and Iraq's oil production which had risen earlier on in order to compensate Iran's oil production drop started get affected as well. Overall, worldwide oil production only dropped of 4% but this was enough to trigger a panic on the markets and crude oil price started to skyrocket again. Whereas oil price had quadrupled during the first Oil Crisis going from $3 to $12/bbl, it nearly tripled this time going from $13 to $36/bbl (*Figure 21*). On more time, this was not necessarily bad news for Texan Oil which gained competitiveness and for the oil companies which posted massive profits during the period.

Figure 25



Evolution of Crude Oil Production of the Main OPEC members during the 2nd Oil Shock

Data from "BP Statistical Review of World Energy" – June 2009

Collapse of the Soviet Union

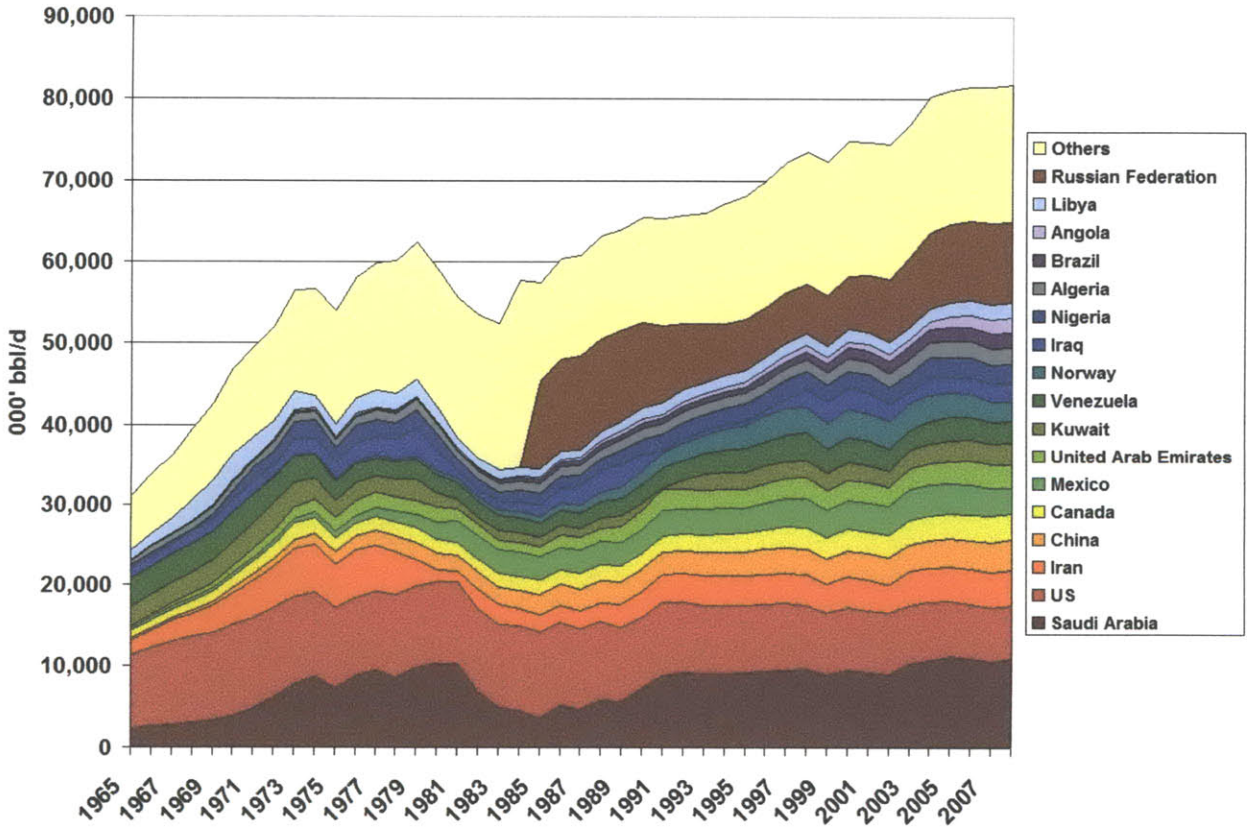
During the First Oil Crisis in 1973, Arab OPEC members put in place an oil embargo against the US in order to put pressure on their supportive foreign policy towards Israel (Yom Kippur War). It arose later that in fact this embargo got shortcut thanks to the unexpected support of... the Soviet Union! As a matter of fact Nixon Administration initiated a policy of "détente" with the Soviet Union led by Leonid Brezhnev in the early 1970's. Hence the Soviet Union bought oil to Iraq and sold it back to the US through Romania, the only Eastern European country which still held diplomatic relations with Israel at that time. This episode already revealed to the US Administration how the Soviet Union was in need for foreign currencies.

Ronald Reagan took office at the White House in 1981 with George Bush Sr. (a former businessman of the oil industry himself) as Vice President. This was the end of the "détente" and Reagan even qualified publicly the Soviet Union of being an "evil empire" in 1983. In a secret note from his Administration Reagan learned that the income of the Soviet Union in strong foreign currencies was dramatically low. The report mentioned $25 billion per year what is to say a quarter of General Motors' or a third of Exxon's revenue whereas the Soviet Union was the largest country and had a population of 250 million people at that time. The report mentioned that Moscow's regime needed the full amount of these foreign currencies to buy food and manufactured products from abroad and also to repay its debt. The support to its allies all around the globe (Cuba, Vietnam, Nicaragua, Angola...) and also the War it started in Afghanistan were very costly as well.

Ronald Reagan who was determined to eradicate the Soviet Union decided to take its financial distress as an opportunity to put his plan into action. He decided to "choke" the Soviet Union financially for good. The main resource of strong foreign currencies of the Soviet Union coming at that time from its oil exports, the Reagan Administration knew that if it managed somehow to "manipulate" the oil markets in order to drop the oil price, it would achieve its goal. As a matter of fact, Reagan Administration had calculated that every

time the oil price would drop of $1/bbl, this would mean a drop of income of strong foreign currencies to the Soviet Union of $1bn per year. In order to achieve their goal, the US needed the support of a country (or some countries) which oil production was large enough to be able to have an influence on the oil price on the markets. Saudi Arabia which oil production accounted for 40% of OPEP countries at that time seemed to be the perfect ally for the success of such a plan. In addition, Saudi Arabia was very concerned about the recent invasion of Afghanistan by the Soviet Union. The Saudis feared that Moscow was in fact eying its oilfields. Therefore, a win-win deal was made between the US and Saudi Arabia. Saudi Arabia would do their best to over-produce in order to keep the oil price down despite the rising demand. In exchange, the US would insure the defense/protection of Saudi Arabia and support the Afghan Mujahedeen against the invasion of the Soviet Union.

Figure 26



Evolution of World Crude Oil Production from 1965 to 2008
Data from "BP Statistical Review of World Energy" – June 2009

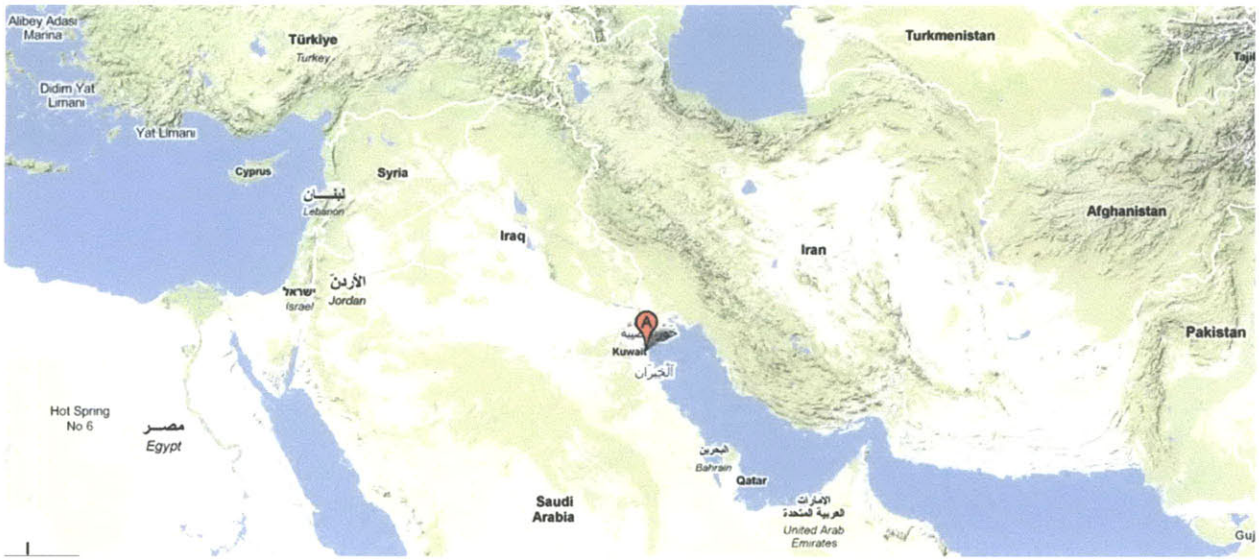
In early 1983, oil price quickly dropped from $34/bbl to $29/bbl. When King Fahd of Saudi Arabia visited Washington in 1985, Ronald Reagan serving his second term managed to convince him that it was in the best interest of both countries to keep the oil price low. Saudi Arabian oil production rose from 2 million barrels a day in early 1985 to nearly 10 million barrels a day one year later. This dramatic oil production rise had the effect to drop the oil price below $10/bbl. As expected, the over-production had a major impact on the income of Soviet Union in foreign currencies. In 1986, the CIA estimated the loss incurred by the Soviet Union to $13 billion. Mikhail Gorbachev (at the head of the Communist Party since 1985) found the Soviet Union close to bankruptcy when he took office.

It is believed that the strategy played by the Reagan Administration has been a major contributing factor leading to the collapse of the Soviet Union some years after. Actually this strategy has been so efficient that it even back-fired to the US oil industry as well. Eventually, Vice President Bush flew to Saudi Arabia in order to convince US allies that it was time to reduce production again and try to stabilize oil price around $20/bbl which was needed for the Texan oil companies to get back to profitability.

Gulf War

Iran-Iraq War ended in August 1988 after 8 years of one of the deadliest conflict since WWII. The conflict cost Iran an estimated 1 million casualties, killed or wounded with the headcount continuing after the war due to side effect of chemical weapons used by Iraq. For Iraq, the headcount was around 500,000 killed and wounded. Saddam Hussein's regime mainly backed by Western countries and by its Arab neighbors appeared as the winner of the conflict over Iran which was supported by the Soviet Union. Even though Iraqi Army was qualified at that time by the Pentagon as the 4th biggest in the World, Iraq ended the conflict completely broke. Whereas Iraq had some reserves before the conflict thanks to its oil revenue, in 1988 its international debt was as high as $130bn, most of it ($70bn) due to Kuwait.

Figure 27



Excerpt from Google Maps centered on Kuwait - Flag "A" in Kuwait City

Right after the cease-fire between Iran and Iraq, Kuwait decided to increase its oil production which was in violation with previous OPEC agreements. In particular, Kuwait decided to increase the production of Al-Rumaylah's oilfields, next to the Iraqi border, a region which ownership had been the subject of ongoing disputes between the two countries. Saddam Hussein considered this gesture from Kuwait as an ultimate betrayal. As a matter of fact, the production rise from Kuwait increased even more over-production at that time which drove the oil price down. This had a dramatic impact on Iraqi revenue which was 90% oil-dependent. With this new drop in oil price, revenue of Bagdad regime dropped down to $7bn per year (vs. $25bn in 1980) what is to say more or less equal to the interest of its debt. Needless to say that this choked the country which was already broke after its costly conflict ($600bn for each party) against Iran.

In 1990, Iraq was not able to pay the interest of its debt anymore. The recent "betrayal" of Kuwait on top of the long lasted territorial disputes plus the fact that Iraq was in need of an access to the Persian Gulf (Iraq only owned a narrow strip of a few miles whereas Kuwait owned most of the access to the Persian Gulf in the region) gave a perfect excuse for the oversized Iraqi troops to invade Kuwait in August 1990. Taking control of Kuwait, Saddam

Hussein became in control of 20% of worldwide oil production. Kuwaiti oil production brought an income stream of $20bn per year. Kuwait also owned a portfolio worth more than $100bn invested all around the world.

Following the invasion of Kuwait, Saudi Arabia increased its oil production of an additional 4m bbl/day in order to compensate the stop of production in Kuwait and the embargo against Iraqi oil. Nevertheless, this effort from Saudi Arabia was not enough to stabilize the markets and oil price started to go up again. Western countries got even more worried when they realized that Iraqi troops were located next to the Saudi Arabian border. Had Iraq invaded Saudi Arabia, it would have been in possession of 40% of worldwide oil production, a risk George Bush Sr. Administration was willing to take. In January 1991, US troops launched the operation "Desert Storm" in order to free Kuwait from Iraqi invasion and to neutralize Iraq. This military operation was a success and with the confidence back on the markets, oil price quickly dropped below $20/bbl. This price remained pretty stable for most of the 1990's.

Recent Past

Several major events have had a noticeable impact on the oil price in the past decade. All of them have been covered in length in the press and the academic research.

Internet Bubble

Oil price followed pretty much the internet bubble of the years 1999/2000. In early 1999, oil price was still below $20/bbl. In November 2000, at its peak oil was worth $36/bbl and when the internet bubble burst oil price dropped down $26/bbl in December of the same year losing nearly 30% in a month.

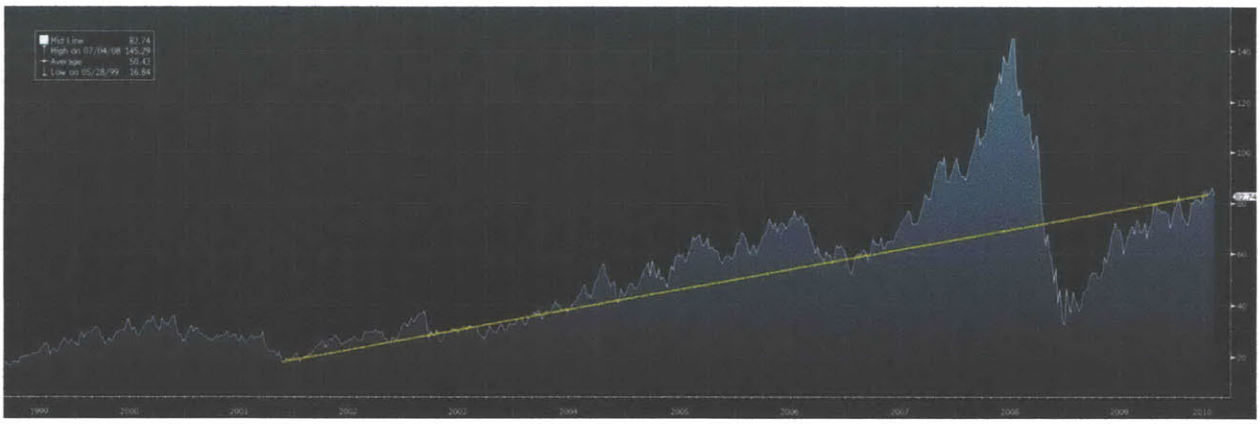
September 11

During most of the first semester of 2001, oil price was oscillating between $25 and $30/bbl. The terrorist attack of the World Trade Centre of New York City in September 11th 2001 was not only followed by a worldwide contraction of the economy but also by a big question mark about the future of the airline industry, a major consumer of petroleum products. End of November 2001 oil price had dropped below $18/bbl losing nearly 40% in two months.

Iraq War

As an aftermath of "September 11" NATO forces lead by USA invaded Iraq in order to defeat Saddam Hussein's regime suspected to support Al Qaeda terrorist organization and also to detain Weapons of Mass Destruction. Early 2003, driven by the speculation of a probable strike towards Iraq which holds the second largest oil reserves in the world, oil price raised above $37/bbl, back to the level it was at the peak of the internet bubble. Quickly after the successful invasion of Iraq by the NATO troops in March 2003, the markets felt reinsured and the oil price quickly dropped below $30/bbl.

Figure 28



Bloomberg West Texas Intermediate (WTI) Cushing Crude Oil Spot Price
Weekly 5/1999 – 5/2010

Figure 28 shows that since the end of 2001 the oil price has followed a mean reversion profile with a upward slope. Oil price has quadrupled in this period going from below $20/bbl in late 2001 to above $80 in May 2010. 3 major events had a noticeable impact on the oil price during this period pushing it away from its mean.

Hurricane Katrina

In August 2005 Hurricane Katrina considered as of the deadliest of the History of the USA was also one of the costliest. Most of the oil rigs in the Gulf of Mexico have been damaged and the oil production has been affected during several months. The drop in annual oil production in the region has been estimated to 24%. This triggered a mini bubble from late 2005 to early 2006 which was followed by a drop in late 2006 given the fact that the hurricane season in the Gulf of Mexico has been relatively mild in 2006.

2007/2008 Bubble

Whereas oil price was already close to its highest level in history in early 2007 (around $60/bbl), it started to skyrocket for nearly 18 months at a rate twice as high as the slope of the mean reversion rate mentioned above. Again, this bubble has been widely covered in the press and in the academic research. Briefly, it can be explained by the conjunction of a surge in demand coming from the emerging countries (especially China and India) and the decline or contraction of supply (peak oil will be discussed later). It is widely accepted that part of the bubble can be attributed to speculation on the markets. In summer 2008, oil price exceeded $140/bbl (+130% in 18 months).

2008 Financial Crisis

Again, the 2008 Financial Crisis has been very well documented but can be summarized with the following major milestones:

- US housing bubble burst and subsequent collapse of the subprime industry
- MBS / CDS / OTC derivative market collapse
- Takeover of Bear Sterns by JP Morgan
- Interbank system freeze
- Rescue of Fannie Mae and Freddie Mac by the Fed
- Takeover of Merrill Lynch by Bank of America
- Bankruptcy of Lehman Brothers
- Rescue of AIG by the Fed
- Collapse of the stock markets all over the world and subsequent contagion to the "real economy".

Oil price did not escape this major financial crisis described by many economists as the biggest since the "Great Depression" of the 1930's. Oil price dropped from $145/bbl in July 2008 down to $31 in December 2008, what is to say a collapse of nearly 80% in less than 6 months.

Fortunately, the recovery of the economy has been significantly quicker than it had been in the 1930's and less than 18 months after the peak of the 2008 Financial Crisis, oil price is already over $80/bbl what is to say back to the mean line of the mean reversion phenomenon described above as also 4 times what it used to be after 9/11 some nine years ago.

In other words, at the light of the events which occurred during the past decade, it would appear that the era of "cheap oil" is definitely over. With supply struggling to catch up with surging demand from emerging countries, it has become nearly impossible for the

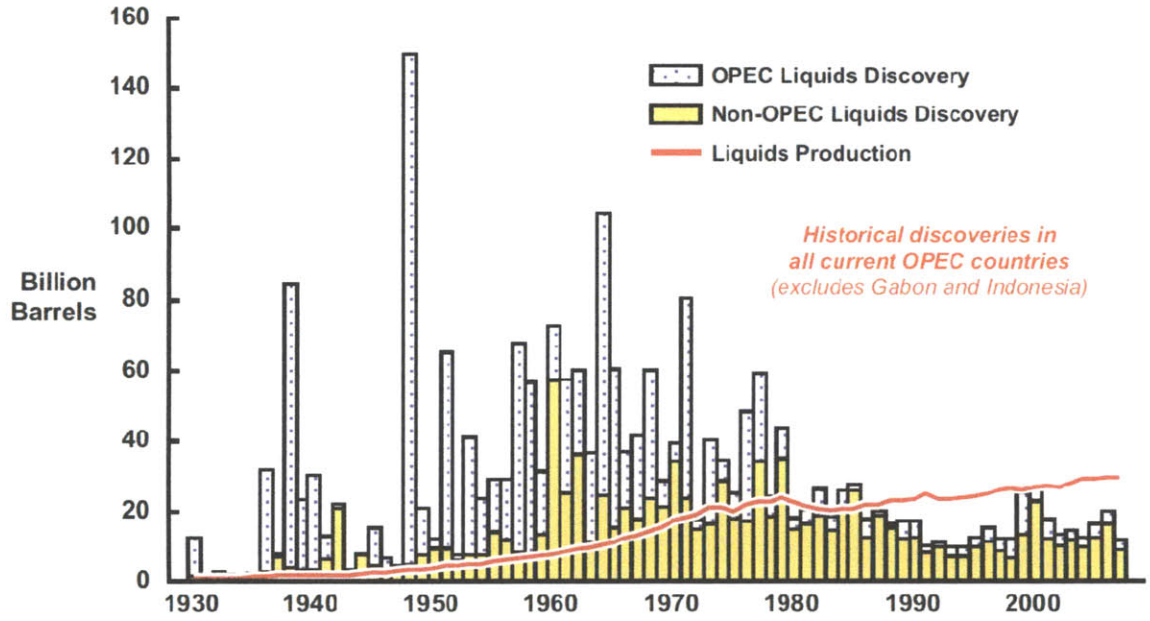
stakeholders to manipulate oil price the way they used to do it for more than a century. Governments from producing countries or from consuming countries as well as oil companies themselves (some of which used to be organized as a "cartel") have to stick more and more to the macroeconomics fundamentals driving the oil price on the markets.

Peak Oil

Given its nature, oil is a natural resource of a finite quantity. Due to its apparent abundance, men have tendency to forget this hard fact. This is forgetting that oil has been used industrially for less than 150 years and has been widely available in western countries only after WWII. As most of us have always lived in the "oil era", we have tendency to believe that supply is inexhaustible. Unfortunately, despite more and more funds spent in exploration, every day way less oil is found on the planet than what is produced which drives us closer and closer to depletion. Figure 29 shows that Peak Oil Discovery has been reached in the 1960's and that oil discovery has never stopped dropping ever since. This graph also demonstrates that production has been consistently exceeding discovery since the mid 1980's.

"Peak Oil" is defined as the moment in time when maximum supply rate (in mbd – million barrels per day) will be reached at world level. Based on observation, the production rate of an oilfield usually first grows exponentially until a peak is reached and then declines over time, sometimes rapidly until total depletion. This notion of "Peak Oil" is important in that once reached no more growth in production will be possible. Assuming that until at least the late 1990's supply has always been able to adapt to a fast growing demand, when "Peak Oil" is reached, there won't be any possibility for supply to match demand anymore. "Peak Oil" is a main driver to the end of the "cheap oil" era.

Figure 29

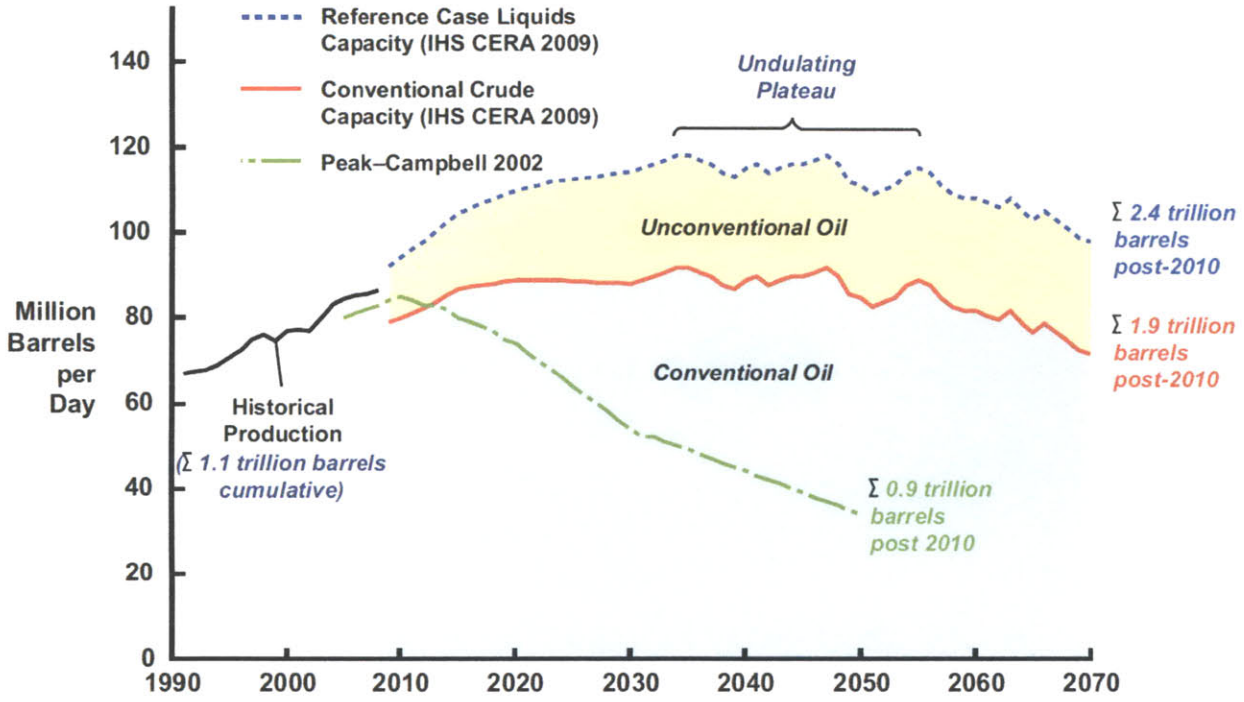


World Liquids Resource Discovery and Production from 1930 to 2007 (source: CERA)

Marion King Hubbert, a geologist working for Royal Dutch Shell has been the first to study the phenomenon in the 1950's in order to try to predict Peak Oil in the USA. Aggregating data from individual oilfields at the national level he had been able to predict accurately as early as 1956 that Peak Oil would be reached in the USA between 1965 and 1970.

Using similar methodology Colin Campbell, another petroleum geologist, predicted that Peak Oil would be achieved by 2010 at world level. Obviously, the matter is highly sensitive and controversial and the date of 2010 is subject to debate. Cambridge Energy Research Associates (CERA) believes that Peak Oil will be achieved in 2030 and will be followed by a 20/30 years long plateau rather than by a quick depletion. According to Campbell, worldwide historic reserves would be in the region of 2 trillion barrels including 1.1 trillion already extracted (0.9 trillion barrels remaining). According to CERA, worldwide historic reserves would be in the region of 3.0 trillion barrels (3.5 trillion including unconventional oil like shale oil) including 1.1 trillion already extracted (1.9/2.4 trillion barrels remaining). It is quite striking to realize how these estimations diverge the one from the other.

Figure 30



Estimation of Oil Supply from 2009 to 2070: Undulating Plateau vs. Peak Oil (source: CERA)

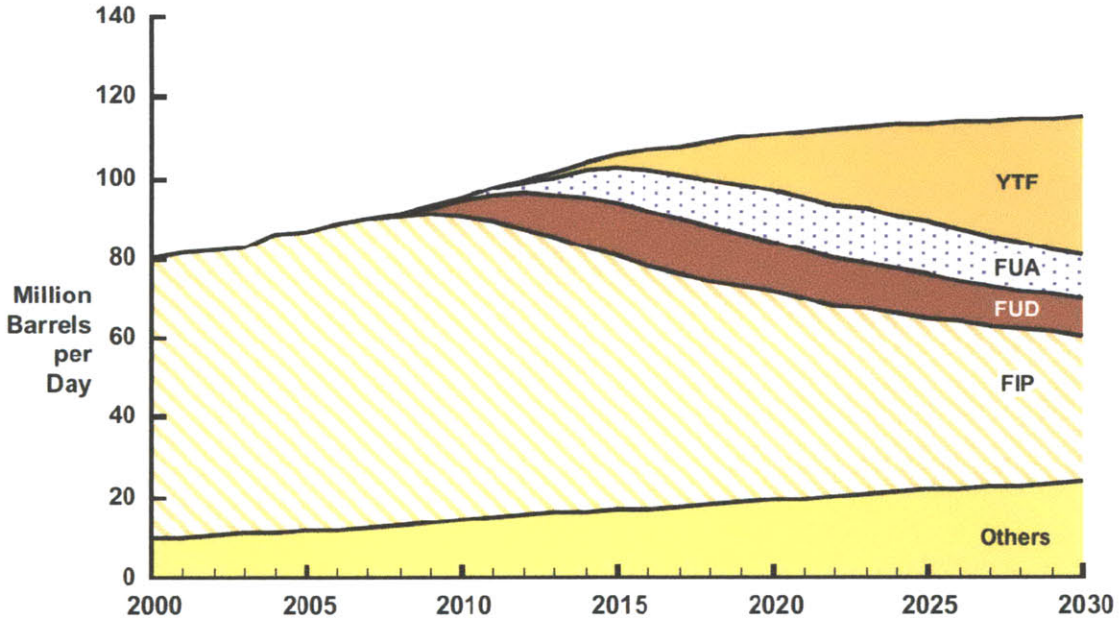
Uncertainty about Peak Oil date is due to the uncertainty about several parameters, the most important probably being "oil reserves" themselves a term which, conveniently, can be rather vague...

First of all, it is quite important to distinguish the notion of "reserves" from the notion of "resources". Oil resource is the finite physical amount of oil contained in an oilfield. Oil reserve is the volume of oil that can be commercially recovered from an oilfield in the future. To start with, it is to be noticed that there is no direct way to measure the volume of the oil resource of an oilfield with 100% accuracy. Hence, technically, oil reserve of an oilfield depends on technology (with today's technology, only 1/3 in average of the oil contained in an oilfield can be extracted regardless of the cost) but on oil price itself as oil will be extracted as long as marginal cost of extraction will be lower than marginal revenue (e.g. oil price). Consequently, when oil price increases, so do the reserves. If reserves are not that easy to assess technically speaking they also are subject to major political issues.

As a matter of fact, it's in the producing countries best interest to overestimate their resources. Doing so, they increase their geopolitical power and influence. OPEC countries also do so because their production quota (therefore a large portion of their annual revenue) is based on their reserves. It's indeed also in the Oil Companies best interest to be "optimistic" with regards to their reserves as well as this is an important part of their valuation on the stock markets. This being said, regulators like the SEC pay more and more attention to the matter. In January 2004, Royal Dutch Shell has had to reveal to the public that the size of its reserves was 20% overestimated. Following the scandal, the CEO, the COO and the CFO all have had to resign and the firm has been fined of $120m by the SEC and of GBP17.0 by the FSA (British regulator).

ASPO (Association for the Study of Peak Oil) cast doubts on a sizeable amount of the reserves officially reported by some countries and some Oil Companies. Figure 31 shows how the "undulating plateau" thesis defended by CERA and most of the Oil Industry itself relies on the oilfields "Yet To Find" (reported as YTF on the graph).

Figure 31

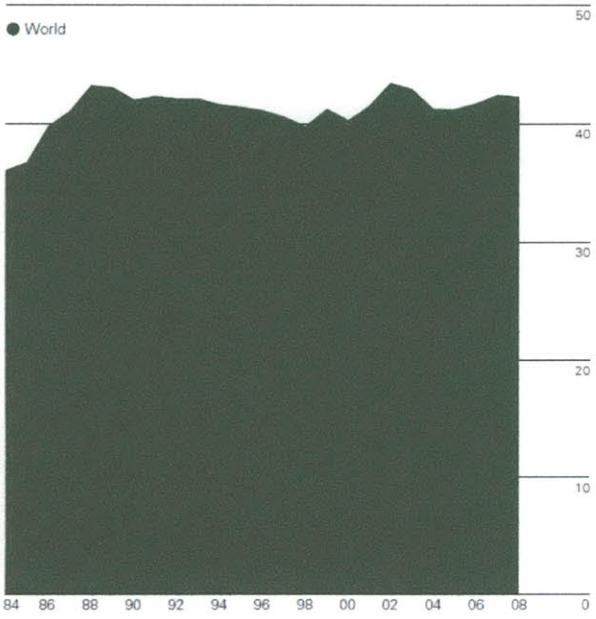


Global Liquids Productive Capacity Outlook (source: CERA)
FIP: Field In Production – FUD: Field Under Development
FUA: Field Under Appraisal- YFT: Yet To Find

Analyzing the official data reported by the industry with a critical eye, one could also notice how "conveniently" steady the "Reserves-to-Production Ratio" has been for the past 25 years (e.g. around 40 years – Figure 32).

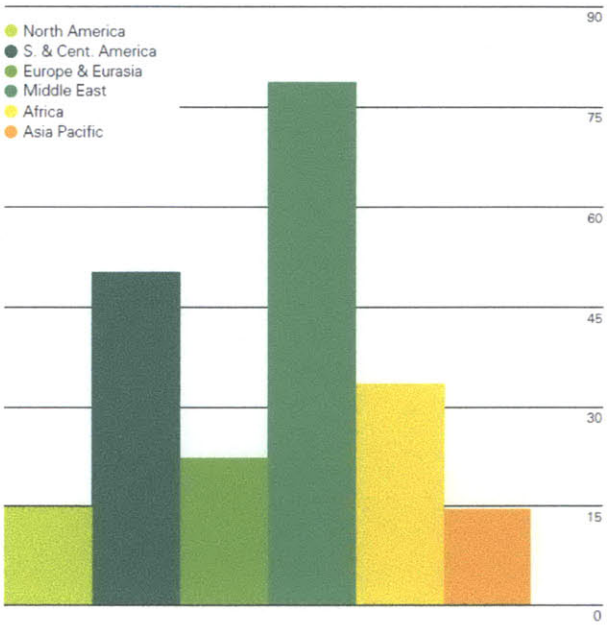
To end with the matter, Figure 33 and Figure 34 illustrate how the world reserves are concentrated in the Middle-East, a region which is not particularly politically stable at the moment (Iraq, Iran...). Figure 35 illustrates how the current world production already depends on the Middle-East (Saudi Arabia, Iran, United Arab Emirates, Kuwait, Iraq...). Obviously, any major political event in one of these countries likely of having an impact on the oil production would definitely get the markets very nervous...

Figure 32



Reserves-to-Production Ratio expressed in years at the world level

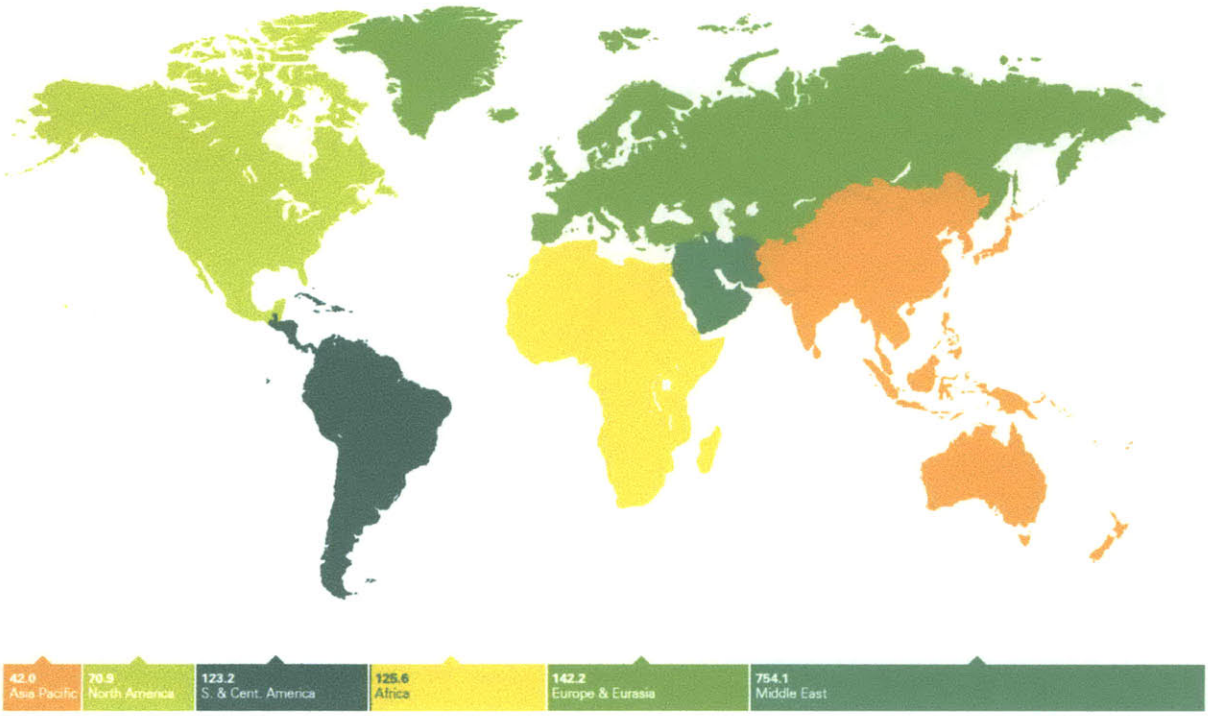
Figure 33



Reserves-to-Production Ratio expressed in years at the world level

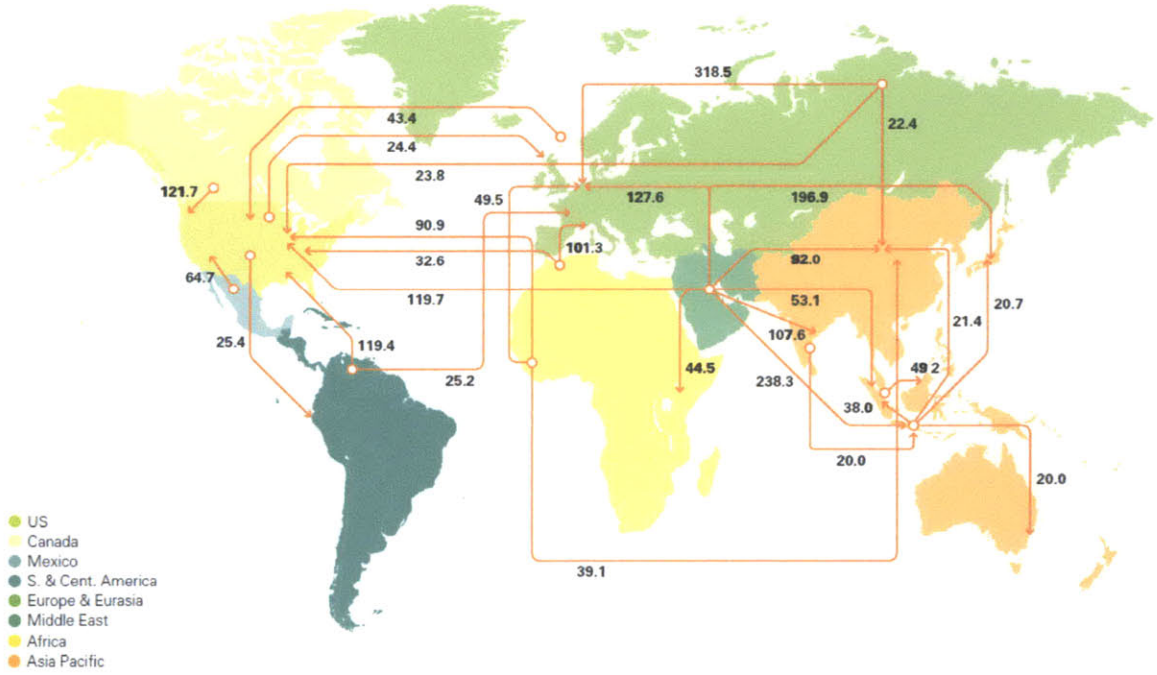
Source: BP Statistical Review of World Energy – June 2009

Figure 34



Proved Reserves at End of 2008 - BP Statistical Review of World Energy – June 2009

Figure 35



Major Trade Movements 2008 – BP Statistical Review of World Energy – June 2009

Can Oil Price be Predicted?

The previous paragraphs have tried to explain ex-post how and why oil price has changed over time. Of course, knowing how things have happened in the past usually helps predicting how they might change in the future. Unfortunately, when it comes to predicting oil price with accuracy, it doesn't seem to be that simple.

In his paper "Understanding Crude Oil Prices", James D. Hamilton analyzes the following perspectives in order to try to build a prediction model:

Statistical Predictability

James D. Hamilton first tries to build a simple regression model with different parameters (real price of oil the previous quarter, interest rate, GDP growth rate), in order to predict oil price rate of change in one, four and eight quarter. Based on a 38 years long data sample (from 1970-Q1 to 2008-Q1), the conclusion is that it is not possible to predict the oil price rate of change using any of the three parameters taken into account.

Using the same 38 years long data sample Hamilton also tries to predict the oil price level as opposed to the rate of change. One again his conclusion is negative and suggests that the real price of oil seems to follow a random walk without drift. He continues adding that the real price of oil is really difficult to forecast. He even goes as far as saying "to predict the price of oil one quarter, one year or one decade ahead, it is not at all naïve to offer as a forecast whatever the price currently happens to be"!

Hamilton finishes his paragraph about statistical predictability with a forecasting exercise for the inflation-adjusted price of oil assuming a Gaussian Random Walk for the logarithm. Starting with an quarterly average price of oil of $115 in 2008-Q1 and a standard deviation of 15.28% over the above mentioned data sample, the 95% confidence interval of the

quarterly price of oil in 2012-Q1 has a lower bound of $34 and a upper bound of $391. In other words, this is not far from flipping a coin or stating that the price of oil in four years will be comprised between zero and infinity...

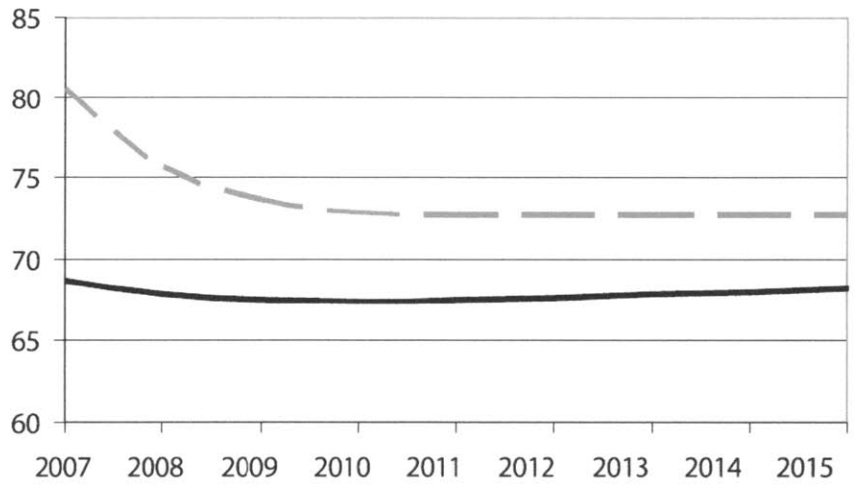
Prediction from Economic Theory

Analyzing the options of storing oil and the cost of carry, Hamilton concludes that "big changes in crude oil prices should be mostly unpredictable".

If not really a scientific a prediction, one could believe that today's Futures Prices are today's view of the market of what the spot price will be in the future. In reality, the theoretical price of a future oil contract is equivalent to the price of borrowing money in order to buy oil today and to hold it up to maturity. You can determine this theoretical price with certainty today. In reality, Oil Futures contracts are usually traded at a price very close to the theoretical price. This means that futures prices are more dependent on today's spot prices than really on today's market's view of future spot prices. Figure 36 illustrates how significantly futures prices with identical long-term maturity evolved in only 40 days following a rise of the spot price during that period of time.

Figure 36

Price of Crude Oil Contract Maturing December of Indicated Years
Solid line: contracts traded on 08.21.07
Dash line: contracts traded on 10.04.07



Understanding Crude Oil Prices - James D. Hamilton- University of California, San Diego

Hamilton reminds that it has been widely accepted for a long time that scarcity rent has historically had a minor influence on oil price adding that if this was undisputed up to the late 1990's this might be about to change as scarcity becomes a tangible issue.

Hamilton ends this paragraph reminding that this is not secret that speculation plays a growing influence on the price of crude oil and that it has been a major contributing factor of the 2007-2008 bubble.

Supply & Demand

Hamilton highlights the low price elasticity of demand (actually lower today than it was in the past), the strong growth of emerging countries in general and China in particular (7% per year. At this rate, China's consumption would match today's US consumption by 2020) and the inability of global supply to increase (already developed in length in the previous paragraph about "Peak Oil") as major contributing factors driving the oil prices in the future.

Conclusion

When questioned about price predictability, Professor Parsons explains that although theoretically it might be possible to predict future oil prices based on statistical and macro-economical analyses, in reality it would require the analysis of too many parameters all of them being highly volatile and extremely difficult to predict.

This being said, this doesn't mean that no attempt is worth trying but wisdom suggests to remaining extremely humble in that matter.

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