Changes in Supply of and Demand for Crude Oil: Implications for Oil Price

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Abstract

The rise in oil prices since the end of the 2007-09 recession has surprised many analysts given the sluggish rate of economic growth in advanced economies. This highlights the changes occurring in the global oil market. This study examines trends in the supply of and demand for crude oil and how they can influence the future price of oil. On the supply side, the main issue is of peak oil or the point at which oil production begins to decline. Analysis of global oil reserve data predicts a peak occurring anywhere from 2014 to 2040. The peaking of production will place upward pressure on oil prices as production capacity declines as oil fields mature, production shifts toward lower quality oil costing more to produce and geopolitical risk rises as global production moves increasingly to OPEC and the former Soviet Union. A major change is also occurring in the global composition of oil demand. Virtually, all future growth in oil consumption will come from developing countries, especially China. Rising demand from them will put upward pressure on prices even if growth remains sluggish in developed countries.

JEL: Q40, Q41, Q47, Q49

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Introduction

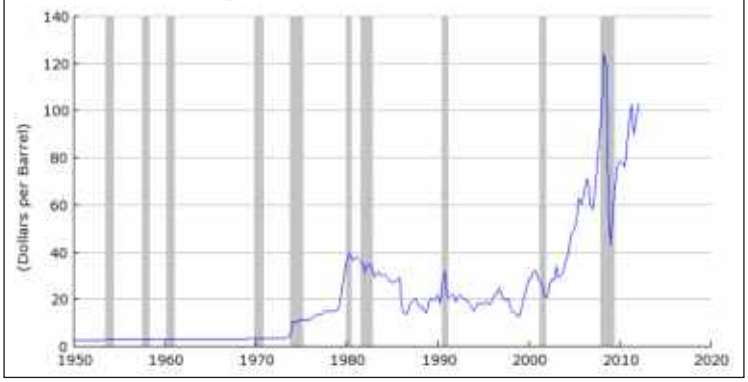
Over the past decade, oil has become a global commodity. In this global marketplace, there have been fundamental changes which will have a large impact on the future price of oil. This study examines these changes focusing on factors determining global supply and demand. On the supply side, the primary issue is peak oil. This refers to the concern that the world is running out of oil and that oil production will soon peak. Numerous doomsday predictions have been made by oil professionals at various times over the past two decades and have failed to come to fruition. Yet, the evidence is growing that these pessimistic forecasts may be right this time and that the era of cheap energy may be over. What is surprising is that despite the critical importance of the issue of peak oil, the topic has not been more widely discussed.

On the demand side, global composition of demand is shifting away from the advanced economies in Europe, Japan and North America towards developing economies, especially those in Asia. This means the impact of the US in determining oil price is becoming less and less of a factor. This study is organized as follows: Section 2 provides a historic review of oil prices, Sections 3 and 4 discuss issues surrounding peak oil, Section 5 examines the changing composition of global demand for oil, Section 6 examines production trends, Section 7 looks at the role of price elasticity. The paper ends with conclusions and implications for oil prices in Section 8.

History of Oil Prices

Given the critical role played by crude oil, events in the oil market have a major impact on overall economy. Over the past 50 years, oil prices have moved in a wide range, but lacked any meaningful trend. As shown in Chart 1, between 1945 and 1972, oil prices, as measured by West Texas Intermediate (WTI), were essentially flat and ranged from $2 to $3 a barrel. Then, the world economy faced two major oil shocks in 1973-74 and 1979-80, both of which were largely due to cutbacks in OPEC production. In 1973-74, oil prices rose from $2-3 a barrel to about $11-12 a barrel and then in 1979-1980 they spiked up again to about $39 a barrel. During both oil shocks, the US and much of the global economy moved into recession and unemployment rates rose sharply.

Chart 1 - Spot Oil Price: West Texas Intermediate



Source: Dow Jones & Company.
Note: Shaded areas indicate US recessions.

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Oil prices peaked in April 1980 at $39.50 a barrel and then steadily declined for almost 20 years, until they bottomed out in December 1998 at $11.28 a barrel. This 20-year period of fall in prices set the stage for the price surge over the past decade. Investments in the oil industry became unprofitable and there was no longer much of an incentive for consumers to conserve energy. As a result, oil companies cut back on their capital budgets and oil rig counts and drilling activity fell sharply. The relatively low price of oil at the pump encouraged consumers to buy less fuel-efficient vehicles and bigger homes. Crude prices starting edging up again at the end of 1990's, but the upward price spike did not become noticeably pronounced until late 2003, with oil prices rising sharply between 2003 and 2008 and reaching a peak of over $130 a barrel in July 2008.

The deepest and longest global recession in the post-World War II period that began in December 2007 and lasted through the middle of 2009, dramatically reduced oil demand and oil prices. Prices for WTI fell from over $130 a barrel in the summer of 2008 to a low of $31 in December 2008. Despite sluggish recovery in advanced countries and record levels of inventories, oil prices trended upwards since the recession ended in 2009 and touched over $100 a barrel by the spring of 2012. Oil prices are now at levels that are well above those experienced prior to the global recession. Oil prices (WTI) averaged around $56 a barrel in 2005 and $66 a barrel in 2006 at a time when the global economy was expanding at a rapid rate. The question is, why are oil prices so high given the sluggish rate of growth in the overall global economy?

Supply Side: Issue of Peak Oil

No one expects the global economy to run out of oil anytime soon. The concern is that the upward trend in oil production, that has been evident over the past century, will reach a point of maximum production and then decline. The question is, when will global oil production peak and how will it affect the global economy? The date when peak production occurs is a source of much debate among participants in the energy market.

Peak oil refers to the point at which a given oil field reaches peak production, after which production will fall, no matter how many new wells are drilled. The ideas underlying peak oil were developed by a Shell geologist, M. King Hubbert (Hubbert, 1956). Back in 1956, Hubbert reviewed the production history of a number of oil fields in the US. He predicted that US oil production would peak in the 1970s, and he called the top within a few months. Since then, crude oil production has been declining in the US, despite the large discovery of oil made on the North Slope of Alaska in the late 1970s.

Applying the same methods to global production, proponents of Hubbert predict that global production should peak in the next few years. Most of today's peakists base their forecast on Hubbert's curve, which is a bell shaped curve representing exponential growth and decline in production (Campbell, 2003 and Deffeyes, 2002 and 2005). Hubbert's curve shows that oil production rises and falls as a direct function of remaining oil reserves. In other words, production can increase until the cumulative production uses up half the total reserves in the field and then production begins to decline. What is critical in the analysis is the half-way point (Campbell, 2003). Once half of the oil is used up we have reached a point of no return and production will decline no matter how much new technology is applied or additional drilling occurs.

Analysis of Global Oil Reserves

The key to Hubbert's peak and the time at which production begins to decline is the level of global oil reserves. We have been consuming oil for over 100 years and have over this period pumped out approximately 1 trillion barrels of oil according to the International Energy Agency (IEA). Current production uses about 31 billion barrels per year. How much oil is left is thus the key question. If we have extracted half of all the oil that has ever existed, we are, by most definitions of the issue, at or past the peak. Obviously, a larger reserve base implies a later peak date than a smaller one. Here is where there is considerable debate among geologists and oil analysts. The peak oil debate revolves around four important issues regarding oil reserves:

1. Amount of oil left to produce.
2. Quality of remaining reserves.
3. Geographic distribution of remaining reserves.
4. Field-by-field analysis.

Amount of Oil

On the issue of the amount of oil remaining, no geologist or analyst knows exactly how much oil exists under the earth or how much can be extracted. Instead, all the reported numbers are essentially informed estimates based on probabilities. In fact, reserve definitions vary by country, making comparisons between them essentially useless. Reserves in a given oil field are classified in a number of categories. The news media nearly always uses the proven reserve figures and omits other categories. By definition, proven reserves are those that can be recovered with reasonable certainty using current technology and current prices. These are often classified as P-90 reserves since there is a 90% probability they will be extracted over the life of the field.

The oil field will also have additional quantities of probable and possible reserves; these are recoverable with a probability of over 50% and under 50%, respectively, from the estimated total volume of oil-in-place in the field. The probable and possible reserves are undeveloped since they are unprofitable to produce at current prices and technology.

Finally, there are unconventional reserves, which include heavy oils, tar sands and oil shale. Processing these reserves is expensive and requires different production methods. While some consider recoverable reserves to be fixed by geology, in reality, their accessibility as energy source is more dictated by technology and oil price changes. ***In other words, economics is as important as geology in coming up with reserve estimates since a proven reserve is one that can be economically developed.***

As technology improves and prices increase, probable and possible reserves are reclassified as proven. This process often leads to a situation where the level of proven reserves in an oil field trends upwards over time in spite of the ongoing extraction of oil from the field. This will occur as the rate of extraction is offset by the conversion of probable and possible reserves to the category of proven. In addition, proven, probable and possible reserves represent only a portion of the oil in place in a given field since it is impossible to recover all the oil and gas. The recovery factor (reserves to oil in place) may change over time in response to improved technology and higher prices. Table 1 provides an estimate of ultimately recoverable reserves (a category that includes proven and probable reserves from discovered fields) as estimated by various sources.

Table 1 - Estimate of Oil Reserves (Trillions of barrels)

	Ultimately Recoverable Reserves
British Petroleum	1.6
Campbell	1.0
Exxon	3.2
International Energy Agency	1.3
Nashawi Kuwait University	1.2
Oil and Gas Journal	1.3
United States Geological Service	2.3

Sources: British Petroleum (2011), C. Campbell(2003), Exxon 2010 Annual Report, International Energy Agency (2008 and 2009), Nashawi (2010), Oil and Gas Journal (2010), and United States Geological Survey (2000).

Thus, the world supply of oil is not only determined by geology, but also by an interplay of economics, technology and most critically important in today's environment, geopolitics. Given the above, the concern is not that we will soon run out of oil in a direct sense. The consensus among most geologists is that we still have about 7-9 trillion barrels of oil-in-place left. The question, is how many of those barrels can be recovered? And, what will be the cost?

Most advocates of peak oil believe about 1 trillion barrels of oil are left. If true, that will put us at or beyond the peak since about 1 trillion barrels have been already produced and production must, therefore, decline. Other geologists estimate ultimately recoverable conventional reserves as high as 3 trillion barrels with another 2 trillion barrels of unconventional oil. Of course, the higher reserve figures yield a much later oil peak, with the USGS numbers suggesting a peak around 2037. A recent study (Nashawi, 2010) by researchers at Kuwait University estimated that the world could ultimately produce 2,140 billion barrels of oil, with 1,161 billion barrels remaining to be produced at 2005 end. This suggests a peaking of production in 2014.

Reviewing the other reserve estimates suggests that the claim that oil production has already peaked seems premature. If the more optimistic assessments hold up, we should have at least another decade or two of rising production, especially if production from unconventional reserves increases as expected. But, even assuming that the peak occurs as late as 2040, a crisis is in the making and preparation must soon begin for the difficult adjustment process of finding reasonable options and alternative energy sources. What is important to understand is that the level of reserves available is not the only factor to consider when creating an effective long-term global energy strategy and oversimplifies the peak oil argument.

Quality of Oil

Quality of oil reserves is also critical due to its impact on the cost of extracting and refining oil. The highest quality, light sweet crude, is easy to find and cheapest to produce and refine. But, most geologists, according to the IEA and US Geological survey, believe that most of the high quality crude oil has already been discovered and its production in existing oil fields is set to decline. Replacing it will be one of several lower, heavier grades of crude (often containing sulfur) that are more expensive to extract and refine. Compounding the problem, it is getting more expensive to discover such new deposits worldwide. For example, recent discoveries of large quantities of crude oil offshore in Brazil and in the Gulf of Mexico involve extremely costly deep water drilling in waters over 2 miles deep. Furthermore, unconventional energy sources such as oil sands in Canada and Venezuela are

expensive to produce and refine and have significant environmental costs. All this suggests that oil prices cannot help but trend upwards in the years ahead as cost of production rises.

Geographic Distribution

Finally, most of the world's proven reserves are found in the OPEC region. The Middle East accounts for over 54% of the world's reserves based on data from British Petroleum (2011) and the International Energy Agency (IEA, 2010). The rest of OPEC has 23% of reserves with Venezuela and Nigeria containing 15% and 3%, respectively. Most of these OPEC reserves are found in countries with high geopolitical risks. Non-OPEC reserves account for 23% of the world total with proven reserves in the US estimated at 2% of total. Exploration, development and production costs are much higher in the non-OPEC region. Most of the fields in the non-OPEC region are mature and in decline.

Field-by-Field Analysis

The rate of change in output from maturing oil fields is critical in assessing the point of peak production. The IEA (2008 and 2009) has compiled a database containing production profiles on the world's 798 largest oil fields. This database includes all 54 of the super-giant fields (proven reserves greater than 5 billion barrels) and 263 of the 320 giant fields (proven reserves greater than 500 million barrels). The bulk of global oil production comes from a small number of super-giant and giant fields. The IEA (2008 and 2009) shows that the 20 largest fields in the world produce over 19 million barrels per day (mbd) or about a quarter of the oil produced in 2008. In addition, the percentage of global production from super-giant and giant fields has grown as a share of total production and accounted for about 60% of global production in 2008 (IEA, 2008 and 2009) compared to around 56% in 1985.

The IEA (2008 and 2009) in an intensive field-by-field study found that 580 of the 798 largest oil fields are at peak or past peak in production. Output in 2008 at 16 of the 20 largest oil fields was below their historic peak. Most of the world's largest fields have been in operation for many years and few large discoveries have been made in recent years except for those in high cost deep offshore waters.

The average annual rate of decline in these 580 fields is 5.1%. This is equal to 3.6 mbd, based on 2008 levels of global production. The rate of decline can be slowed through the deployment of new secondary and enhanced recovery techniques, but this is extremely capital intensive and significantly increases the cost of producing a barrel of oil. The problem is that once production exceeds its peak, it is difficult to slow the rate of decline even if large investments are made. In fact, peak oil analysis suggests that the rate of decline will accelerate once oilfields exceed peak production. A key implication of the analysis is that future supply must not only meet rising demand, but also offset the loss of capacity from existing fields as they mature. In fact, loss of capacity will have a more important impact on future supply needs than the increase in demand.

In summary, what the oil reserve data suggests is that we are not running out of oil per se, but that we are running out of high quality low cost oil and large-scale investment in future energy supply is needed to offset large declines in global production capacity.

Changing Composition of Global Demand

Perhaps, the most important development on the demand side of the oil market is the rising

importance of emerging market economies. Tables 2 and 3 provide historic consumption data for 1980 to 2010 and projections out to 2030. The following section presents a review of the historic data and then looks at a projection of oil demand.

Historic Data

What is evident in the data is that the composition of global oil demand is rapidly changing. Mature economies in the US, Europe and Japan still account for over half of global consumption, but their share is declining. The share of oil consumption in advanced countries has declined from 62.2% in 1980 to 49.9% in 2010. What is happening is that most of the growth in the demand for oil is coming from emerging/developing countries. Due to a combination of rapid economic growth and an expanding manufacturing and transport sector, emerging economies are quickly cornering a larger pie of global oil consumption. Growth in manufacturing and vehicle ownership is the most important driver of oil demand in these countries.

It is not surprising that the booming emerging economies have posted robust oil demand. This is especially true of China and India, with their GDPs growing at an annual rate of around 10% and 8%, respectively, over the past 5 years, with no reasonable expectation of a slowdown. From the historic oil consumption data provided in Tables 2 and 3, following observations are made:

- As is shown in Chart 1, oil price rose significantly in the decade of 1970s. Oil consumption responded to these price hikes with a lag as there was virtually no growth in global oil demand between 1980 and 1990. Oil demand rose from 64.8 mbd in 1980 to only 67.0 mbd in 1990. Demand in mature economies declined by 400,000 mbd over this 10 year period.
- Between 1990 and 2000, global oil demand rose by 9.6 mbd as economic growth worldwide was relatively strong. Despite the robust increase in demand, both nominal and inflation-adjusted oil prices declined through most of the decade and bottomed out in late 1998.
- What was striking in the oil market in the decade of the 1990s was the sharp contraction in oil consumption in the former Soviet Union from 8.1 mbd in 1990 to 4.3 mbd in 2000.
- Global oil consumption grew at a rapid rate between 2000 and 2010 despite the deep 2007-09 recession. Between 2000 and 2010, demand for oil increased by 9.4 mbd from 76.6 mbd in 2000 to 86.0 mbd in 2010.
- Most of growth in oil demand between 2000 and 2010 has been due to growth in consumption in emerging economies. Between 2000 and 2010, oil consumption in emerging economies rose by 11.2 mbd accounting for all of the incremental growth in global demand over this period. In contrast, consumption in advanced economies declined by 2 mbd.
- China alone increased consumption by 4.4 million barrels per day between 2000 and 2010. Demand in India and the rest of Asia rose by 2.6 mbd from 2000-10.
- Changes in the price of oil are largely determined by incremental growth in demand. Emerging economies, given their rapidly expanding consumption, will increasingly account for most of the overall incremental demand growth for oil and thus become one of the primary determinants of oil price.

Table 2 - Global Oil Consumption by Region (Million Barrels Per Day)

	1980	1990	2000	2010	2015	2030
Mature Economies						
US	17.4	17.0	19.7	19.0	20.6	21.6
Europe	14.6	14.2	14.6	14.1	14.3	14.8
Japan	4.9	5.3	5.5	4.4	4.3	4.5
Other*	3.3	3.4	5.1	5.4	5.8	6.2
Total Mature	**40.3**	**39.9**	**44.9**	**42.9**	**45.0**	**47.1**
Former Soviet Union	**9.5**	**8.1**	**4.3**	**4.5**	**5.0**	**5.5**
Emerging Economies						
China	2.0	2.3	4.7	9.1	11.1	16.6
India	0.7	1.2	2.3	3.3	3.7	5.1
Rest of Asia	4.0	4.1	6.4	8.0	9.1	10.9
Latin America	5.0	5.6	6.8	7.8	8.4	9.6
Middle East	2.0	3.7	4.9	7.1	7.5	9.0
Africa	1.3	2.1	2.3	3.3	3.5	4.1
Total Emerging	**15.0**	**19.0**	**27.4**	**38.6**	**43.3**	**55.3**
Total World	**64.8**	**67.0**	**76.6**	**86.0**	**93.3**	**107.9**

Source: US Energy Information Administration (EIA, 2011) and British Petroleum. (2011).
Note: Other consumption in the table is oil demand in Canada, Korea and Australia & New Zealand.

Table 3 - Change in Demand By Region (Million Barrels Per Day)

	Change in Consumption 2000-10 (mbd)	Projected Change in Consumption 2010-30 (mbd)
Advanced Economies		
US	-0.7	2.6
Europe	-0.5	0.7
Japan	-1.1	0.1
Other	0.3	0.8
Total Mature	**-2.0**	**4.2**
Former Soviet Union	**0.2**	**1.0**
Emerging Economies		
China	4.4	7.5
India	1.0	1.8
Rest of Asia	1.6	2.9
Latin America	1.0	1.8
Middle east	2.2	1.9
Africa	1.0	0.9
Total Emerging	**11.2**	**16.7**
Total World	**9.4**	**21.9**

Source: US Energy Information Administration (EIA, 2011) and British Petroleum (2011).
Note: Other consumption in the table is oil demand in Canada, Korea and Australia & New Zealand.

Demand Projections

Global oil demand is projected to increase from 86.0 mbd in 2010 to an estimated 93.3 mbd in 2015 and an estimated 107.9 mbd in 2030 based on projections made by the US Department of Energy (2011). The US Energy Information Administration (EIA, 2011) forecast is essentially a consensus forecast and is consistent with projections made by the International Energy Agency (IEA) and most private analysts.

Oil consumption in the emerging economies will increase by an estimated 16.7 mbd between 2010 and 2030 and account for most of the growth in global oil consumption. Oil consumption is expected to increase by 4.2 mbd in advanced economies over this period. China alone will increase its consumption by 7.5 mbd between 2010 and 2030 accounting for over 34% of the global increase in oil demand.

Growing vehicle ownership will play a key role in oil demand growth. Of the projected increase in oil use over 2010-30, 62% occurs in the transportation sector. Statistical studies by EIA (2010) and IEA (2008 and 2009) indicate that demand for motor vehicles rises rapidly once per capita income exceeds $3,000. A growing portion of the population in China and India is now approaching this threshold level of per capita income and thus both countries will experience a significant surge in rates of motor vehicle ownership. In summary, the growing absolute size and importance of demand in emerging economies will have a major impact on price trends in the oil market.

Production: Non-OPEC Supply

We now look at the non-OPEC supply side of the oil market. Growth in non-OPEC oil supplies has played a significant role in the erosion of OPEC's market share over the past three decades. Production surged in Alaska, the North Sea, South America and Mexico and recently in Africa. Many of these oil fields are now aging and production is expected to decline. ***It is non-OPEC supply that will experience the impact of peak oil.***

Table 4 - Non–OPEC Production (Million Barrels Per Day)

	2000	2010	2015	2030
US/Canada	11.1	13.3	14.6	18.2
Mexico	3.5	2.9	2.3	1.5
Europe	5.8	4.5	3.5	3.1
Former Soviet Union	10.7	13.2	14.6	17.4
Africa	2.5	2.6	3.0	3.5
Latin America	3.6	4.8	6.2	8.9
Rest of world	9.0	10.4	10.5	10.4
Total Non -OPEC (Includes unconventional)	**46.2**	**51.7**	**54.7**	**63.0**
Unconventional Production	1.3	4.8	6.2	11.7
Total Non-OPEC Less Unconventional	**44.9**	**46.9**	**48.5**	**51.3**
Total Less Unconventional and Former Soviet Union	**34.2**	**33.7**	**33.9**	**33.9**

Source: US Energy Information Agency (EIA) Annual Energy Outlook (2011).

Table 4 provides supply projection for Non-OPEC countries to 2030 based on EIA estimates. The forecast assumes that conventional production (outside the former Soviet Union) stays essentially flat through 2030 as effects of peak oil become evident. Oil production increases due to growth in the former Soviet Union and gains in nonconventional production. The EIA assumes significant growth in non conventional production with production increasing from 4.8 mbd in 2010 to 11.7 mbd by 2030. It is important to point out that unconventional production is capital intensive, expensive to produce and with large environmental impacts. The extent to which these unconventional resources will be utilized hinges on the price of crude and the cost of mitigating their impact on environment. Oil markets will be adversely impacted if either former Soviet Union or unconventional production falls below expectations.

Growing Dependence on OPEC

Comparing the demand forecast provided in Table 2 with non-OPEC supply projections in Table 4, we can calculate the residual demand for OPEC oil. This is the amount of oil OPEC must produce to close the gap between global demand and non-OPEC supply. The results are provided in Table 5. Most long-term projections of oil supply and demand simply assume that OPEC production is a residual that will be available to meet market demand.

Table 5 - Growing Dependence on OPEC (Million Barrels Per Day)

	2000	2010	2015	2030
Global Demand	76.6	86.0	93.3	107.9
Less Non OPEC Supply	46.2	51.7	54.7	63.0
Need for OPEC Oil	**30.4**	**34.3**	**38.6**	**44.9**

The need for OPEC oil will grow from 34.3 mbd in 2010 to 44.9 mbd in 2030. These amounts to a significant increase in OPEC output over a 20-year period. Most of the production increases will occur in the highly politically unstable Middle East. Essentially, the above analysis indicates that OPEC countries must find the equivalent production capacity of another Saudi Arabia over the next 20 years. Such a sizeable expansion in oil production capacity will prove to be a daunting challenge for OPEC producers and will require a huge financial investment in both oil capacity and the infrastructure to transport it.

Implications of Dependence on OPEC

The growing projected reliance on OPEC production has the following implications:

1. Oil is a global market, therefore, once non-OPEC production peaks and demand continues to grow, there will be strong upward pressure on oil prices.
2. Despite the two price shocks in 1973-75 and 1979-1980, oil prices, after adjusting for inflation, have been essentially flat for the past 40 years with no clear trend. This is about to change. Over the next few decades, oil prices are expected to trend upwards and do so well above the inflation rate.
3. The world currently has little surplus oil capacity.

According to EIA, spare global capacity is at its lowest in 30 years. Tight capacity is likely to be an ongoing characteristic of the oil market in the future, given the expected slowing in non-OPEC production.

4. With little spare capacity, oil prices will be highly volatile and will respond quickly to any sudden change in demand or supply.
5. There are major questions as to whether OPEC countries or countries in the former Soviet Union will have the required financial wherewithal and technology to expand oil production to meet global market needs. This will create further uncertainty in the oil market.
6. Much of OPEC's production is in countries with high geopolitical risk. With a growing reliance on OPEC oil, a speculative risk premium will be a permanent feature in the oil market.
7. The threat is especially acute in Venezuela, where nationalistic policies could lead to a sharp drop in foreign investment and in output. At risk are foreign oil companys' plans to finance the commercial development of an estimated 235 billion barrels of extra-heavy oil found in the Orinoco Belt.

Supply Issue: Need to Offset Production Declines

Global oil production must expand over the next two decades not only to meet the expected increase in demand, but also to offset declining production in existing oil fields. As we noted earlier, many of the largest oil fields have been producing oil for decades and are likely to be close to a production peak and an eventual decline. The IEA (2008) estimated that oil production from existing oil fields is declining at an annual rate of 5.1%. Given this rate, the question is how much capacity must be added between 2010 and 2030 just to offset the production declines.

IEA (2010) data estimated global oil production capacity in 2010 at 85 mbd. With no addition to reserves, global production capacity will decline to 31.4 mbd by 2030 assuming an annual rate of decline of 5.1%. Thus, gross capacity of 53.6 mbd must be added by 2030 to compensate for declining production in existing fields. This estimate is probably conservative since the rate of decline is likely to accelerate over the next two decades.

Impact of Price Elasticity

The key unknown in the above projections is the eventual responsiveness of global demand and non-OPEC supply to higher prices. In economics jargon, we are referring to the concept of the elasticity of demand for and supply of oil. Elasticity measures responsiveness of consumption and production of oil to changes in its price. In other words, the coefficient of elasticity measures the extent to which consumption growth will slow and production will rise in response to higher prices. Estimates of the demand and supply price elasticity for oil vary widely, but consensus shows that elasticity rises significantly with time as both businesses and consumers make adjustments in their spending habits and production decisions. Economic theory predicts that over longer periods, oil demand and supply should be highly responsive to price (a high level of elasticity). Historic data completely supports this prediction. In fact, the decades of 1970s and 1980s provided a perfect test of this theory.

Consistent with economic theory, the high price of oil in the 1970s was followed by a surge in non-OPEC investment and production in the 1980s. At the same time, following the 1979-1980 price shock, demand for oil stagnated for over 10 years. Surprising to many analysts, the global economy

expanded at a healthy rate in the 1980s with essentially no growth in oil demand (energy-efficiency improved dramatically). What the data clearly shows is that in response to the higher oil price, there was a sharp slowdown in growth in demand for oil in the 1980s while its supply rose. These results are just as predicted by economic theory and indicate a high value for the long run elasticity of demand and supply.

Understanding the concept of elasticity has important implications for the future outlook of the oil market. Forecast in Tables 2 and 3 assumes that oil prices rise at the inflation rate through 2030 (real price of oil is unchanged). If oil prices were to rise at a faster rate (not an unreasonable assumption), projection of future global demand will be considerably lower, and at the same time, higher production is likely from non-OPEC sources. The global demand and non-OPEC supply imbalance will be considerably less, as will be the need for OPEC production. The important point to understand is that higher the oil price, the more important is the elasticity effect. This means that demand will expand at a slower rate and supply will expand at a faster rate in response to the higher price of oil. This, in turn, will limit the extent to which oil prices rise (because of lower demand and higher supply).

Conclusions and Implications for Oil Prices

The oil market is undergoing fundamental changes. On the supply side, global oil production is likely to peak in the next few decades. The exact peak date is difficult to determine, but a careful analysis of global oil reserve data suggests it could occur as early as 2014 or as late as 2040. The impact on global oil supplies will be dramatic even if peak production occurs at a later date since global production capacity is already falling due to aging of oil fields.

On the demand side, growth in oil consumption will come entirely from emerging countries, with little growth in demand in advanced countries. Thus, pressure to add to oil production capacity is coming from both supply and demand sides of the oil market. Table 6 summarizes the amount of new oil production capacity that must be added globally by 2030 to meet growing global demand and to offset production declines.

Table 6 - Estimated Needs for New Oil Producing Capacity (Million Barrels Per Day)

Additional Oil Capacity need to:	2010-2030
Meet global demand	21.9
Replace loss of capacity due to aging of fields	53.6
Total	**75.5**

The results show that oil production capacity must increase by a staggering 75.5 mbd by 2030 to meet demand growth and replace depleted supply. This capacity increase is more than twice the level of current OPEC production. In fact, as shown in the above table, the loss of capacity will have more important impact on future supply needs than the increase in demand. What makes the situation even more challenging is that peak oil analysis indicates that the rate of decline will accelerate with the increase in the age of oil fields. If this prediction is correct and peak production occurs in the next few years, there will be an even greater need to discover more oil to offset the larger declines in production.

In addition, most new capacity coming on stream will be of lower quality, more difficult to refine, with higher production costs and located in countries with high geopolitical risk. Given the need to replace a significant and growing amount of capacity and the growing demand from emerging economies, oil prices should rise considerably over the next two decades.

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