CHAPTER 1

Energy Commodities and Price Formation

"If a commodity were in no way useful…, it would be destitute of exchangeable value, however scarce it might be, or whatever quantity of labour might be necessary to procure it."

—David Ricardo

Throughout history, the availability of sources of energy and the means to produce, transport and harness it efficiently have been a necessary conditions for the growth of civilizations. Over the last century, fossil fuels have become the dominant source of energy globally, and companies have explored new sources and developed new technologies to access these reserves. But what is fuel without fuel consumers? Fossil fuels could have remained a topic confined to geologists' circles if it were not for the development and popularity of fossil fuel-based transportation machinery – such as cars, planes, and ships – has made these fuels essential to human life. It has been suggested that the usage of fossil fuels is an important factor behind the doubling of the world's population over the last century. Over the past few decades, the scarcity or abundance of these resources has been significantly influenced by the demand for these fuels, as consumers develop new uses for fuels, use fuels more efficiently, or substitute them with other energy sources.

This chapter emphasizes the strategic nature of energy commodities and introduces the energy markets by discussing the principal fuels transacted, the uses of these fuels, their origin, and how they are brought to market. Thereafter, the chapter examines the factors that influence fuel prices, including geopolitical risks and short-term supply/demand balances, as well as long-term fuel market considerations that contribute to the volatility of energy prices.

ENERGY AS A STRATEGIC RESOURCE

The importance of energy for present-day society cannot be understated. Energy is ubiquitous in the modern world, with every conceivable product and service utilizing energy for its production and delivery. Consequently, fluctuations in energy prices affect entities at all levels – from households and small businesses to large companies and governments – and the impact of price volatility is easily apparent. Rising energy prices impact a family's consumption basket, causing everything from transportation to groceries to become more expensive, thereby reducing their purchasing power. Higher fuel prices also mean that companies need to either absorb higher costs, raise output prices to maintain profitability, or otherwise manage the rise in costs. Finally, governments need to balance the subsidies given to energy consumers against deterioration in trade and budget metrics (e.g., fiscal and trade deficits) and potential social unrest. Even governments of energy-rich countries need to calibrate the amount of social support provided during periods of high energy prices in order to maintain a buffer for years when energy prices are low.

This increased awareness of the centrality of energy resources has been accompanied, over the last 30 years, by the development of sophisticated financial markets, the advent of the Internet, and electronic trading technologies allowing for more "democratic" access to commodities trading. Nowadays, investors, hedgers, and speculators are able to take control of thousands of oil barrels without leaving their chairs. Very often, the person trading these commodities has no personal experience with the physical commodity. Anyone can buy and sell commodities on trading platforms without even knowing the color of palladium, the location of gas pipelines, or the sea lanes used by very large crude carriers (VLCCs). Such abstraction from the details of the underlying physical commodity and its supply chain may be tolerable for some commodities, but is not advisable in the case of a "strategic" resource such as energy. The issue of security of production and supply is especially important for energy commodities, and this gives them a strategic dimension. Even experienced professionals like energy economists, who do a good job explaining energy prices in terms of supply and demand, can falter if they overlook the cost of securing supply and the security of trade routes.

To understand the importance of these details in the case of energy markets, let us use the analogy of a computer or a tablet. One can think of the commodities' physical platform as the hardware and the financial system as the software installed on it. The luxury of the touch screen and user-friendly graphic interfaces makes electronic technology easily accessible to everybody, to the point that one forgets about the existence of electronic circuits. It is perfectly understandable that more and more users find the workings of the hardware irrelevant, as long as they can use the apps. However if, hypothetically, the computer were to be used in conjunction with other devices to control the heartbeat or any other vital organ in the body, the concerned person would insist on learning about the safety mechanisms of the hardware, reading the manufacturer reviews, and even renegotiating his/her insurance scheme. Similarly, energy security cannot be discussed without a proper understanding of the commodities' physical platform. In a world where major energy chokepoints are prone to instability or turbulence, it is reasonable to assume that consuming nations must, directly or indirectly, bear the cost of securing energy supplies.

To further illustrate the strategic nature of energy, let us consider the case of China, which has become a major part of the energy equation, accounting for a significant fraction of oil demand growth. As a major oil consumer, China now commands the attention of market participants, who keep a close eye on the growth rate of the Chinese economy as any signs of a slowing of growth could send oil prices south. This simplistic analysis sometimes depicts China as mainly responsible for recent oil price volatility, either due to inappropriate monetary policy or industrial overcapacity, among other reasons. However, the situation looks quite different when viewed in the context of the petrodollar system.

Since the onset of the petrodollar system in the 1970s, most Asian oil-importing economies, including China, were obliged to export goods to the United States to lay their hands on the US dollars that were necessary to procure oil from Saudi Arabia and other Organization of Petroleum Exporting Countries (OPEC) members. China has been successful in leveraging its large workforce to build a significant manufacturing infrastructure capable of meeting (or exceeding) the US market demand for manufactured goods. This status quo has helped China to build an industrial complex, the OPEC countries to enjoy unprecedented purchasing power, and the USA to pay for goods and services in a currency it can control or even "print." The consequence of this system is that, in the absence of credible alternative counterparties, economies like China are very vulnerable to contractions in US imports, while the USA keeps the option to shift manufacturing to other countries like Bangladesh or Vietnam. As China's internal market cannot absorb its industrial production at international prices to cover US dollar-denominated commodity costs, any contraction of US imports can have a social impact (such as unemployment) in China and similar repercussions for neighboring economies. With a very large population aspiring to participate in its economic growth, China needs to maintain a minimum level of gross domestic product (GDP) growth, which requires incremental commodities that can only be purchased when margins from exports are significant. If this were not the case, then growth would likely be borrowed from the future in the form of bad loans. Such complex challenges faced by China and other exporter nations are intimately related to the energy market but are not readily apparent just from trading screens.

Therefore, it is important for market participants to be alert to the geopolitical factors impacting energy prices and the importance of maritime route security and energy chokepoints. In this regard, we will take a closer look at China and how it is reducing its exposure to the petrodollar system through the use of oil and gas trade-offset mechanisms with Russia. We will also discuss how it aims to limit its reliance on the Strait of Malacca and the troubled South China Sea for its energy imports. But before that, we will look at different types of commodities, some characteristics of energy commodities, their provenance, and how they are refined and transported.

ENERGY AS A TRADABLE COMMODITY

The commoditization of energy resources unfolded in an accelerated fashion after the collapse of the Bretton Woods system, which ultimately led to the inauguration of crude oil trading on the Chicago Board of Trade (CBOT) and the New York Mercantile Exchange (NYMEX) in 1983. The Bretton Woods system of fixed exchange rates was replaced by a floating exchange rate system that gave rise to increased volatility in financial markets in the 1970s. The need to manage exchange rate volatility led to the development of markets for foreign exchange. Concurrently, oil-producing countries were very concerned about the declining US dollar and started adjusting oil prices to match changes in gold price. In other words, there was reluctance in the oil market to break from the old Bretton Woods system that was pegged to gold. This kept oil prices stable when expressed in the old, "gold-backed dollars" but led to volatility spikes in actual oil prices (expressed in post-Bretton Woods US dollars). Thus, the evolution of the oil market from a regulated market with price controls to a free market necessitated the development of instruments for oil price risk management, akin to agricultural commodities markets. The development of this market depended heavily on the successful commoditization of these energy resources.

A commodity can be defined as any good or service for which there is demand and which is indistinguishable from other goods of the same type. That is, there is no special feature or additional utility provided by a particular good that is not available from another good of the same type. For example, crude oil produced in the USA is fungible with crude oil produced elsewhere in the world and can be used for similar purposes. Thus, all goods of the same type are treated as equivalent and this facilitates the formation of markets as commoditized goods become substitutable for each other. In practice, commodities which are traded on commodity markets have to adhere to a minimum standard or grade in order for them to be widely traded.

In this book, the use of the term "commodity" will refer to physical goods, usually natural resources, which are grown, mined, or extracted and are traded in a marketplace. The price of the commodity is generally determined by the market as a whole and not by individual producers or consumers. This assumes that a commodity is not differentiable by source, quality, or other specifications. However, in real life, there are minimum standards of quality and quantity that need to be observed for products to be traded in a marketplace. These minimum standards enable trading of large quantities of commodities as buyers do not have to bear the costs of analyzing the provenance of underlying commodities for each transaction. Markets also assign value to quality differences and, by extension, to the sources of commodities. For example, crude oil with low sulfur content and higher fractions of high-end products such as gasoline and kerosene (called light sweet crude oil) is usually assigned a higher price than crude oil with higher sulfur content.

As opposed to other asset classes such as stocks or bonds, which represent claims on a corporation or entity, commodities are more difficult to define as an asset class. They can range from precious metals, such as gold and silver, to agricultural products like corn and wheat, as well as energy products such as crude oil and natural gas. Commodities can trade across physical markets, where participants exchange the actual commodity, or financial markets, where participants exchange claims to underlying commodities (akin to stocks and bonds). In this respect, commodities are better understood by observing the markets in which they are traded.

Commodities can have multiple sources, making classification on this basis impractical. For instance, gold mined in Australia is substantially similar to gold mined elsewhere in the world. It is easier to classify commodities based on shared characteristics such as physical state, method of production, and primary end use. Commodities can be broadly classified under four major classes.

1. *Precious metals*. Metals such as gold, silver, platinum, palladium, rhodium, etc. can be classified as precious metals. This classification derives from their historical usage as currency, and their scarcity relative to other metals.
2. *Base metals/industrial metals*. Metals such as copper, aluminum, zinc, nickel, lead, and tin are some of the major base metals traded in global markets. The name "base metals" derives from their tendency to oxidize or corrode, as opposed to noble or precious metals. In mining, the term "base metals" generally refers to non-ferrous metals, excluding precious metals, while the term "industrial metals" expands the definition to include other commonly used metals such as iron and steel.
3. *Energy commodities*. Commodities that are used for the production of energy come under this category. They include crude oil, derivatives of crude oil such as naphtha, gasoline, gasoil, heating oil, and fuel oil, in addition to natural gas, coal, electricity, biodiesel, and

other commodities. Petrochemicals, emissions, and freight, which have close linkages to the energy market, can also be considered as energy commodities.

4. *Agricultural commodities*. Agricultural commodities encompass a wide range of commodities produced by farming. They can be further divided into sub-classes, based on their usage, availability, and the similarity of their markets.
   a. *Food grains*. Commodities mainly used for human consumption, like rice, wheat, corn, etc.
   b. *Edible oils and oilseeds*. Oils fit for human consumption, including soybean oil, palm oil, soybeans, soybean meal, rapeseed (canola) oil, sunflower oil, etc.
   c. *Livestock*. Live animals, which are mainly live cattle, feeder cattle, and lean hogs.
   d. *Soft commodities*. Other agricultural commodities such as cotton, coffee, cocoa, sugar, orange juice, rubber, etc.

Increasingly, there are linkages between classes of commodities such as energy and agricultural commodities. Commodities such as sugar or palm oil are used not only as food, but also to generate energy in the form of biodiesel. However, we use the aforementioned classification as it is based on the primary usage of the commodity and the major driver of demand for that particular commodity.

ENERGY COMMODITIES

Energy commodities come in different physical forms: solids such as coal and wood, liquids like petroleum, and gases such as natural gas and propane and butane (that are converted into Liquefied Petroleum Gas (LPG)). Most energy commodities in use are hydrocarbons, although nuclear energy and hydroelectric power are notable sources of power that are not hydrocarbon-based.

The main sources of primary energy are oil, natural gas, coal, nuclear energy, hydroelectric power, and renewables. Many of these primary sources are used in the generation of electricity, a secondary form of energy. The International Energy Agency (IEA) provides details on the supply and consumption of oil and other energy commodities. A breakdown of the total primary energy supply (TPES) of the world is shown in Figure 1.1. Oil and coal are the biggest sources of energy, with natural gas not far behind. Of these forms of energy, oil, coal, natural gas, and biofuels are traded in regional and global markets.

The total final consumption of energy provides a picture of the end uses of primary energy (without including backflows from the petrochemical industry). It can be inferred by comparison with primary energy supply that a significant proportion of primary energy sources, especially coal and natural gas, are converted into electricity for final use. As per the IEA, 63.7% of oil is consumed for transportation, while industrial use of coal accounts for 80% of its annual consumption (Figure 1.2).

Let us now briefly consider individual energy commodities, starting with crude oil.

Crude Oil

Crude oil or petroleum, derived from the Latin: petra (rock) + oleum (oil), refers to the thick, usually dark-colored liquid that occurs naturally in different parts of the world and is commonly retrieved by drilling. Petroleum is a fossil fuel, which was formed when a large

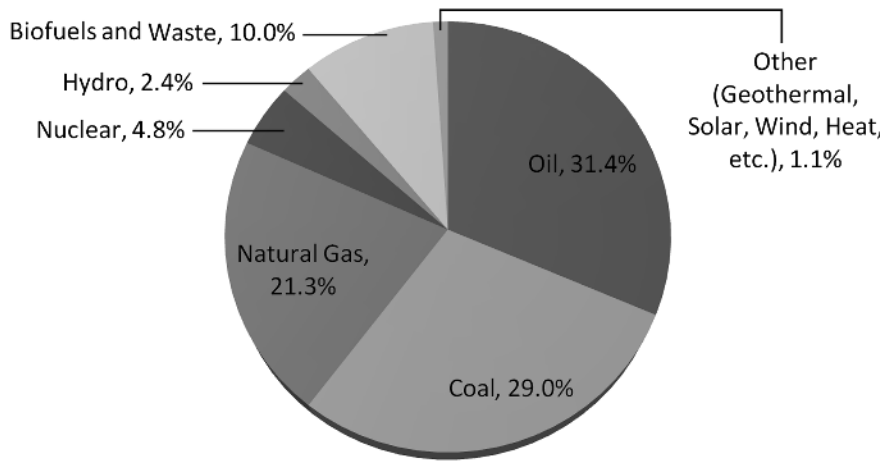

FIGURE 1.1 Total primary energy supply for 2012; TPES totaled 13,371 Mtoe (million tons of oil equivalent)
Source: International Energy Agency, © OECD/IEA 2014, Key World Energy Statistics, IEA Publishing; modified by John Wiley and Sons Ltd. License: www.iea.org/t&c/termsandconditions.

number of dead organisms were buried under sedimentary rock and subjected to enormous heat and pressure over millions of years. Crude oil is the most prominent of the hydrocarbon-based fuels, compounds composed mainly of carbon and hydrogen in varying proportions.

Since crude oil on its own is not of much use and needs to be processed for most modern applications, the value of crude oil is derived from the value of the underlying refined products that are obtained after processing. The products that can be obtained from refining a particular grade of crude oil depend on the chemical characteristics of the crude oil. Since crude oil obtained from an oil well will differ slightly in quality from oil drilled from any other well, it is instructive to look at the overarching physical properties and characteristics that determine the value of a particular grade of crude.

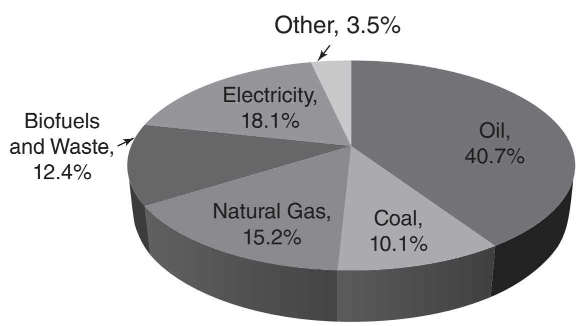

FIGURE 1.2 Total final consumption for 2012; TFC totaled 8979 Mtoe (million tons of oil equivalent)
Source: International Energy Agency, © OECD/IEA 2014, Key World Energy Statistics, IEA Publishing; modified by John Wiley and Sons Ltd. License: www.iea.org/t&c/termsandconditions.

The major properties of crude oil that are referenced in most contracts and specifications are the density, sulfur content, viscosity, pour point, volatility, water content, and sediment and other impurities. Other properties that are applicable to oil products include the flash point, cloud point, stability, dye, etc.

Density is measured using the American Petroleum Institute (API)s gravity scale, which is a measure of how much heavier or lighter the petroleum liquid is compared with water. A reading of above 10 indicates that the liquid is lighter than water and floats on it. Crude oil with a high API gravity value is referred to as light crude oil and would yield a higher percentage of lighter or less-dense products such as gasoline and kerosene upon refining. Crude oils with a low API gravity value are termed heavy crudes and are more difficult to refine, yielding lesser quantities of the high-value lighter products.

Sulfur is an undesirable impurity as it is corrosive and foul smelling, and it needs to be removed during the refining process. Crude oils with a sulfur content of less than 0.5% are referred to as “sweet” crude oils, while those with a sulfur content greater than 0.5% are termed “sour” crudes.

Viscosity is a measure of the thickness of the fluid or the resistance that it offers to pouring. It is measured in centistokes or Saybolt universal seconds. The pour point is the lowest temperature at which the crude oil retains its flow characteristics and below which it turns semi-solid. These measures are essential to determine the means of storage and transportation for liquids.

Volatility of crude oil and other products is measured using the Reid vapor pressure test and is important for handling and treatment considerations. Vapor pressure is especially important for gasoline as it affects starting, warm-up, and vapor locking tendency during use. Water content and sediment content are measured, as they are indicative of the effort needed to remove these impurities.

The main crude oil benchmarks are West Texas Intermediate (WTI) Crude Oil, which is a US crude oil, and Brent Crude Oil (North Sea crude oil). Both of these crudes are light sweet crude oils, where the API gravity is greater than 31.1°. Dubai Crude Oil is a major benchmark in the Asian region and is classified as a medium crude oil (API between 22.3° and 31.1°). Some of the major crude oil streams, along with their properties, are shown in Table 1.1.

TABLE 1.1 Major crude oil streams and their properties

	Crude oil stream	Country	API gravity	Sulfur (%)
1	West Texas Intermediate	USA	38.7	0.45
2	Brent Blend	UK	38.5	0.41
3	Arab Light	Saudi Arabia	32.7	1.8
4	Urals	Russia	31.8	1.35
5	Bonny Light	Nigeria	33.6	0.14
6	Maya	Mexico	21.8	3.33
7	Tapis	Malaysia	45.2	0.03
8	Kuwait	Kuwait	30.5	2.55
9	Basrah Blend	Iraq	34.4	2.1
10	Iran Light	Iran	33.4	1.36
11	Dubai	Dubai – UAE	30.4	2.13
12	Bow River	Canada	19.6	2.92
13	Murban	Abu Dhabi – UAE	39.6	0.79

Oil Products

Crude oil is too volatile to be used on its own, and hence distillation of crude oil into various fractions of different volatility is needed. The main types of oil products in descending order of volatility are:

- gases and LPGs
- gasolines/naphthas
- kerosenes
- gasoils/diesels
- fuel oils
- lubricating oils, paraffin wax, asphalt, tar, and other residuals.

Methane and ethane are gases found with petroleum. Methane, which is also referred to as “natural gas,” is used for energy generation while ethane is used as a feedstock for petrochemical production, where it is converted into plastics. LPGs refer to propane, butane, or and a mixture of the two. They are used for cooking and industrial purposes. Gasoline is used mainly for motor transportation. Gasolines or naphthas are also used as feedstock for the petrochemical industry and refineries.

Kerosenes are mainly used as aviation turbine fuel (ATF). They are also still used for lighting and cooking in some parts of the world. Gasoils are used principally for home heating or as diesel engine fuel. They are also used as petrochemical feedstock. Fuel oils are used in marine transportation (also known as bunker oil) or as a source of fuel at refineries or power stations.

The refining process involves the separation of hydrocarbons by state and size, processing and treating individual products for the purpose of removing impurities and converting, or cracking, heavier hydrocarbons into lighter, more desirable compounds (Figure 1.3). The first stage of refining involves fractional distillation, whereby the crude oil is heated to a high temperature, usually around 350°C, and pumped into a distillation column where a temperature gradient is maintained between the top and the bottom. Lighter components of the crude oil, which boil at lower temperatures, condense at higher levels of the column while heavier compounds settle at lower levels of the column. Off-take pipes at different heights of the column withdraw fractions of different compounds, with gases and LPG at the top of the tower and fuel oils and residuals at the bottom. This residue from atmospheric distillation can further be subjected to vacuum distillation to remove more volatile components of the residue, leaving behind asphaltenes and other heavy residues.

Following distillation, the oil products are subjected to hydro-treating or Merox treating, whereby the sulfur present in the products is removed. Hydro-treating involves mixing hydrogen gas with the oil product (usually naphtha or gasoline) and passing the mixture over a catalyst at high temperature and pressure, resulting in the sulfur being removed as hydrogen sulfide gas.

The next major step in the refining process is the conversion of fractions into lighter, more desirable compounds. Naphthas are subjected to a process of catalytic reforming or platforming, whereby the “octane number,” a measure of performance of motor fuels, is increased using a catalyst like platinum. Heavy residues are subjected to thermal cracking (heating to temperatures in excess of 400°C) or catalytic cracking, where a finely divided catalyst is mixed with the feedstock and heated, to produce catalytic-cracked gasoline and other light products. Hydro-cracking, another catalytic cracking process that uses hydrogen, can also be used for this purpose.

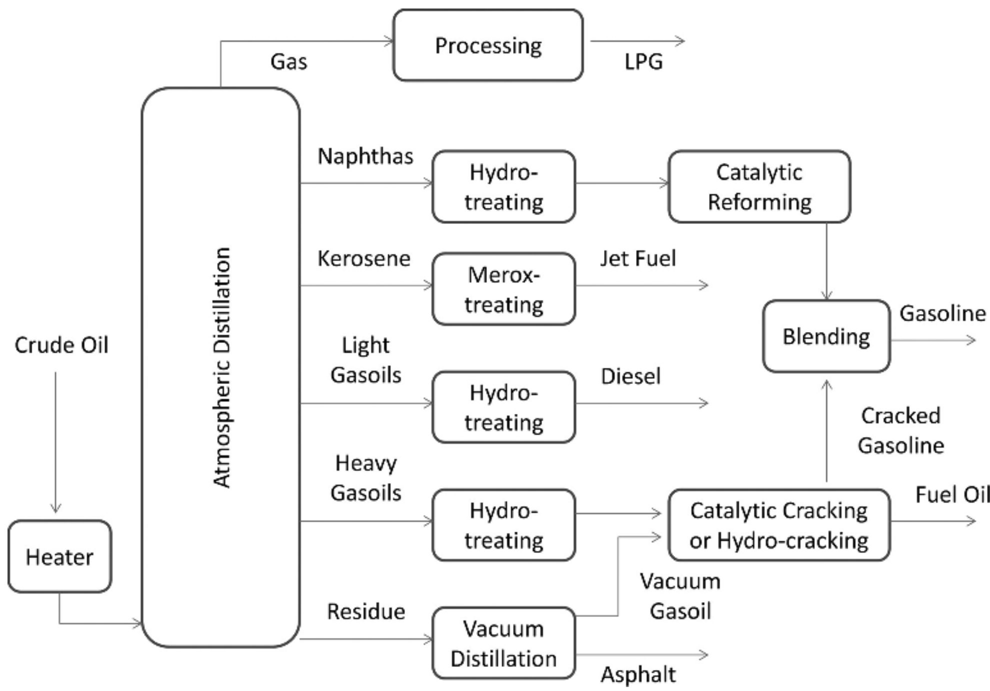

FIGURE 1.3 Simplified refining process diagram

The final step in the process is blending, where different products produced at the refinery are mixed in certain proportions to form the finished products, which conform to certain standards. For example, oxygenates are blended with motor gasoline to reduce the lead content and increase the octane number of the fuel.

Prior to refining, a crude oil assay is conducted to get a good idea of the product yield (i.e., the fraction of each product that can be obtained from the particular grade of crude oil). With crude oils of a similar origin, the crude grade with a higher API gravity value is likely to yield higher-end products; however, an assay is the best means of getting a reliable estimate of product yield. Sample product yields from primary distillation of Brent Crude Oil and Dubai Crude Oil are shown in Tables 1.2 and 1.3.

TABLE 1.2 Brent Crude Oil distillation yields by percentage of weight

Product type (boiling range)	Product yield (% by wt.)
Gas and LPG (C1 to C4)	2.4
Naphtha (C5 to 149°C)	19.1
Kerosene (149°C to 232°C)	14.2
Gas oil (232°C to 342°C)	20.9
Atmospheric residue (342°C+)	43.4

TABLE 1.3 Dubai Crude Oil distillation yields by percentage of weight

Product type (boiling range)	Product yield (% by wt.)
Gas and LPG (C1 to C4)	1.5
Naphtha (C5 to 180°C)	18.6
Kerosene (180°C to 240°C)	10.4
Gas oil (240°C to 380°C)	28.1
Vacuum gas oil (380°C to 550°C)	21.3
Residue (550°C+)	20.1

A test of the types of hydrocarbons present in the feedstock for the refinery can also be conducted to identify the appropriate feedstock to be used. This is called a PONA (paraffins, olefins, naphthenes, and aromatics) analysis. Feedstock that is rich in paraffins is better used as a petrochemical feedstock as it cracks easily. Olefins do not occur naturally in crude oils but are produced by refining processes and are present in other feedstock like naphthas and gasolines. Naphthenes and aromatics have higher octane numbers and are more suitable for refineries.

The product yields are used to calculate the gross refining margin. This is calculated by multiplying the product yields with the prevailing product prices and subtracting the cost of crude oil used. Some of the popular local product benchmarks are listed in Table 1.4. Calculating refining margins is essential to maintain the profitability of the refining operation, as refineries have flexibility in terms of choosing the optimum crude oil grade to use, changing the operation of the refinery to produce different fractions of products, blending, and the storage of products.

TABLE 1.4 Selected local product benchmarks

Region	Asia Pacific & Middle East	Europe	Americas
Crude oil	Dubai Crude Oil	Brent Crude Oil	WTI Crude Oil
Naphtha	MOPJ (Mean of Platts Japan) Naphtha; Singapore Naphtha	Naphtha CIF NWE (North West Europe); Naphtha Med (Italy) or Rotterdam Barges	Naphtha FOB USGC
Kerosene	Singapore Jet Kero	Jet NWE	Jet 54 USGC; Jet Fuel LS New York Harbor
Gasoline	FOB Singapore Gasoline 92 RON	Gasoline 10 ppm FOB MED; Eurobob Gasoline FOB ARA (Amsterdam Rotterdam Antwerp)	US Gulf Coast Gasoline
Gasoil	Singapore Gasoil	ICE Gasoil	No. 2 Heating Oil
Fuel oil	Singapore High Sulfur Fuel Oil (HSFO) 180 CST and HSFO 380 CST	Fuel Oil 3.5% Rotterdam Barges	FO RMG 380

Natural Gas

Natural gas is another fossil fuel, which is naturally found along with crude oil or coal and is formed in a similar manner (i.e., the exertion of high pressure and temperature over millions of years, by geological processes, on the remains of plants and animals). The main constituent of natural gas is methane (CH_4). Natural gas, when produced along with crude oil, is called associated gas. When crude oil is found in small quantities along with primarily natural gas, it is called condensate. Natural gas can also be extracted from coal reservoirs (known as coalbed methane), and landfill gas and biogas also contain high quantities of methane. Natural gas usually occurs with impurities such as water vapor, carbon dioxide, mercury, nitrogen, and hydrogen sulfide, as well as other gases such as ethane, propane, butane, and heavier hydrocarbons, which when liquefied are called natural gas liquids (NGLs). These impurities need to be removed before natural gas can be transported.

Natural gas is transported through pipelines or is liquefied to transport using liquefied natural gas (LNG) carriers. In this case, regasification facilities are required at the terminal where LNG is transported to. Since the heating use of natural gas is seasonal, gas needs to be stored for the winter season. Natural gas is "injected" into underground facilities like depleted gas reservoirs, salt caverns, and aquifers or stored within pipelines or as LNG.

Natural gas is the cleanest-burning hydrocarbon and is increasingly being used for electricity generation. It is used for heating and cooking and as feedstock for chemical manufacturing. It is also used as fuel for vehicles, which run on either compressed or liquid natural gas, and it can further be converted to other fuels using gas-to-liquid processes. Ethane is used for manufacturing plastics, while propane and butane are used as LPG. Heavier NGLs consist of gasoline, naphtha, and kerosene fractions and can be blended with crude oils.

Natural gas markets are much more localized than other energy markets and multiple pricing methods prevail globally; this has allowed only a few benchmark prices to attract sufficient market liquidity. The benchmarks that have gained popularity include Henry Hub Natural Gas in the USA, the National Balancing Point (NBP) in the UK, and Zeebrugge and TTF (Title Transfer Facility) in Continental Europe.

Coal

Coal is a black or dark-brown combustible sedimentary rock that is formed by the carbonization of vegetation and is composed primarily of carbon, along with varying proportions of hydrogen, nitrogen, sulfur, and oxygen. It generally occurs in rock strata, in layers called coal beds or coal seams. There are various grades of coal, classified based on the amount of time spent under intense heat and pressure, which affects their chemical properties. Lower-rank coals such as peat, lignite, and sub-bituminous coals have lower amounts of carbon by weight and are more volatile. Higher-rank coals include anthracite and bituminous coal, which have higher carbon and, thus, higher heat content.

Anthracite coal is primarily used for heating. Bituminous coal can be divided into two types – thermal or "steam coal" and metallurgical or "coking coal." Steam coal is mainly used for power generation and as an energy source for cement production, while coking coal is used to produce coke, which acts as a reducing agent in the production of pig iron and subsequently, steel. Lignite and sub-bituminous coals are mainly used for power generation. Coal can be converted into liquids to use as alternate fuels for transport, cooking, power generation, and in the chemicals industry. Coal can also be converted to syngas, a mixture of carbon monoxide and hydrogen gas, and subsequently used to produce electricity or other transport fuels.

Global coal markets can be split into two major regions – the Pacific basin and the Atlantic basin. The major benchmarks for thermal coal are based on delivery at ports where coal is exported from or imported to, and include Newcastle coal (Australia), API4 coal (Richards Bay, South Africa), and API2 coal (Amsterdam Rotterdam Antwerp, ARA). Further, local coal markets like the USA have their own benchmarks.

PRICE DRIVERS IN ENERGY MARKETS

Prices in physical markets are influenced by a myriad of factors. As in most markets, supply and demand play a major role in price determination. Commodity prices are also generally linked to economic performance, with growing economies consuming more commodities, and thus raising prices. Commodity prices are also influenced by events affecting the supply chain of the product, from producers and refiners to distributors and consumers.

As a number of energy commodities are considered strategic assets and their production is concentrated in the hands of a few countries, which are largely emerging economies that can be prone to instability, there is a geopolitical aspect to price determination as well. As commodities get increasingly financialized, with major financial players like banks and hedge funds trading in these markets, commodity prices have also become linked to other asset prices.

Let us examine some of these factors briefly, using the oil markets as an example.

Geopolitical Risks

Oil prices are particularly vulnerable to events such as war, internal strife, or terrorist attacks, especially in the sensitive Middle East region. For example, oil prices spiked in the wake of the Gulf War and the Iraq War of 2003, as well as during the "Arab spring" rebellions across a number of countries in North Africa and the Middle East. In such environments, oil prices trade at a premium to prices implied by supply/demand balance, and this is sometimes dubbed the "fear premium." In contrast, resource nationalism, in the form of higher royalties or outright nationalization of assets, has been decreasing in recent years and many national oil companies are opening up to collaboration with global oil companies due to the scarcity of capital and technological know-how needed to exploit new reserves.

The Geopolitical Chessboard – The Petrodollar System and Rising China

Earlier in this chapter we discussed the strategic role played by energy resources and touched on how the pricing of this commodity can impact the destiny of large nations. The fact that more than 60% of the global production of oil moves on maritime routes makes naval power integral to securing the supply of oil and thereby shaping the world's geopolitical chessboard. By far, the USA is the mightiest naval power in the world and has been successful in providing protection to major oil producers and securing the maritime routes, thereby deserving the privileges of the petrodollar system. Other rising powers, like China, have also relied on US-led maritime route security to secure the energy imports required to build an industrial complex and accelerate their economic growth. However, it is only recently that these nations have begun viewing these energy maritime routes as the source of vulnerability that they are and have taken steps to address these weaknesses and reduce their exposure to the petrodollar system.

The Strait of Hormuz, the Strait of Malacca, the Suez Canal, Bab El Mandab, the Danish Straits, the Bosporus and, to a lesser extent, the Panama Straits are the major oil chokepoints, representing the most strategic locations that have shaped the geopolitics of the last 40 years. The most strategic and troubled chokepoint remains the Strait of Hormuz, which has been used as a bargaining card by Iran to negotiate with the West and put pressure on neighboring oil-producing countries.

In the case of China, the world's second-largest oil-consuming nation, the situation is much more complicated, because its oil imports need to move through two major chokepoints and a troubled South China Sea, as shown in Figure 1.4.

China imports over 70% of its crude oil from the Middle East and the traditional sea route has been through the Indian Ocean, the Strait of Malacca, and the South China Sea. China remains concerned about its security of sea lanes, especially those passing through the Strait of Malacca and the South China Sea, through which an estimated 80% of its oil imports transit. Also, in the absence of a significant global naval presence, China is not comfortable relying on oil imports passing through the South China Sea, which is surrounded by countries that are perceived to be part of a US-led containment coalition. These potentially hostile countries include the Philippines, Japan, and Taiwan, which were once referred to as an "unsinkable aircraft carrier" by General MacArthur. As a nation that is not a US ally, China fears the disruption of its oil imports in the case of hostilities in the region.

In order to alleviate the disruption risks, China has done a formidable job developing trade links with its Central Asian neighbors and building infrastructure in close South Asian neighbors to gain access to the Indian Ocean. Together with Pakistan, China has been developing a megaproject called the China Pakistan Economic Corridor (CPEC) consisting of a network of highways, railways, and oil and gas pipelines over 3000 km running from the port of Gwadar all the way to Kashgar in China. The CPEC will give China access to the Arabian Sea not far from the Strait of Hormuz. Similarly, China gained access to the Bay of Bengal via Sino-Burma pipelines, which transport oil and gas from the port of Kyaukphyu to Kunming (Yunnan Province). In addition to cutting the shipping time of Middle Eastern and African crude oil significantly, these two shortcuts are game-changers on the chessboard as they help avoid crowded South China Sea waters and any unexpected hostilities in transit. Additionally, as mentioned earlier, China has also been working closely with its neighbors in the east and the north, signing megaprojects allowing Russia to trade its oil and gas in Yuan or Roubles using trade-offset mechanisms to minimize its dependence on the US dollar and related unpredictability in financing costs.

Oil prices are particularly vulnerable to events such as war, internal strife, or terrorist attacks, especially in the sensitive Middle East region. For example, oil prices spiked in the wake of the Gulf War and the Iraq War of 2003, as well as during the "Arab spring" rebellions across a number of countries in North Africa and the Middle East. In such environments, oil prices trade at a premium to prices implied by supply/demand balance, and this is sometimes dubbed the "fear premium." In contrast, resource nationalism, in the form of higher royalties or outright nationalization of assets, has been decreasing in recent years and many national oil companies are opening up to collaboration with global oil companies due to the scarcity of capital and technological know-how to exploit new reserves.

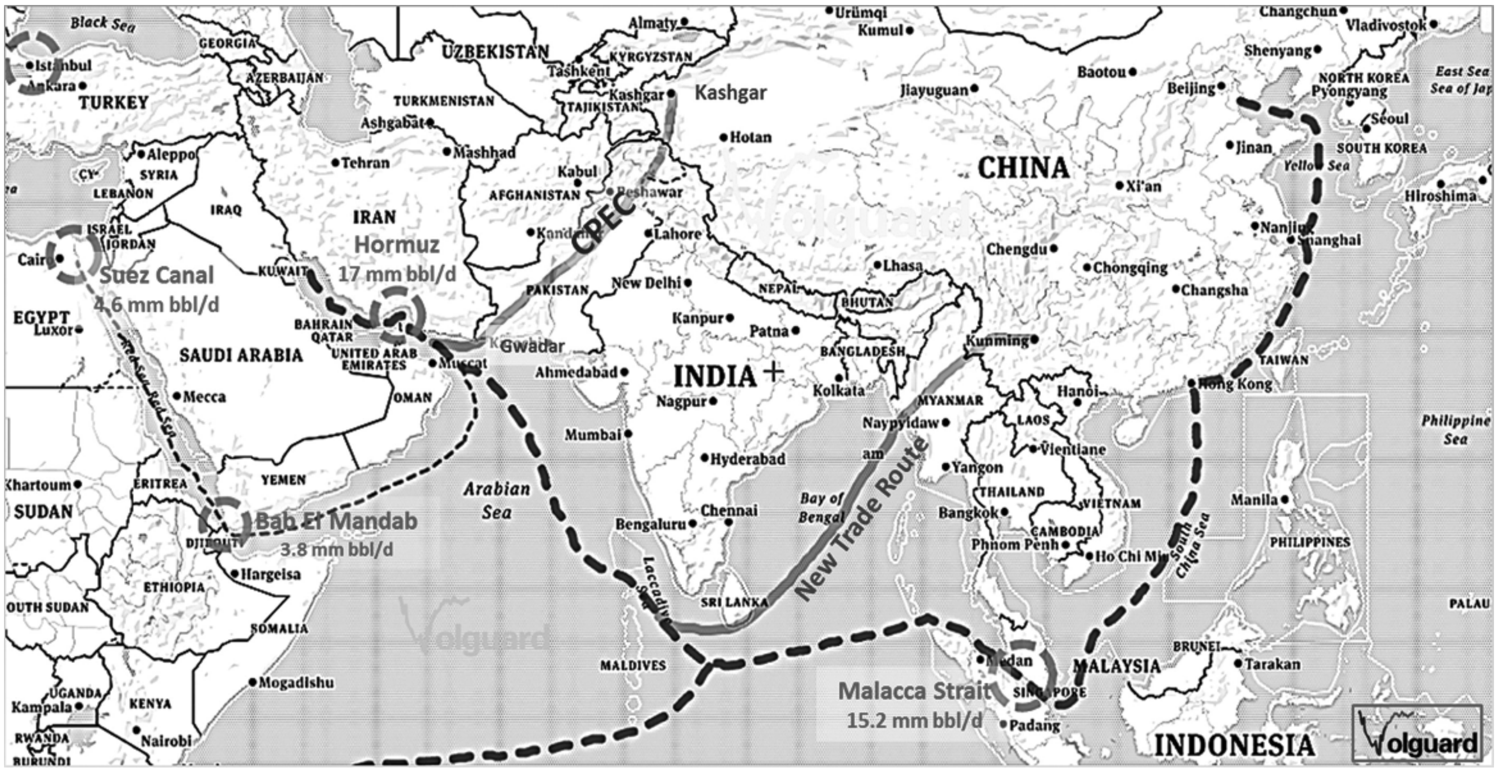

FIGURE 1.4 Oil maritime routes and chokepoints
Data Sources: US Energy Information Administration analysis based on Lloyd's List Intelligence, Eastern Bloc Research, Suez Canal Authority, and UNCTAD, using EIA conversion factors. Estimates are for year 2013.

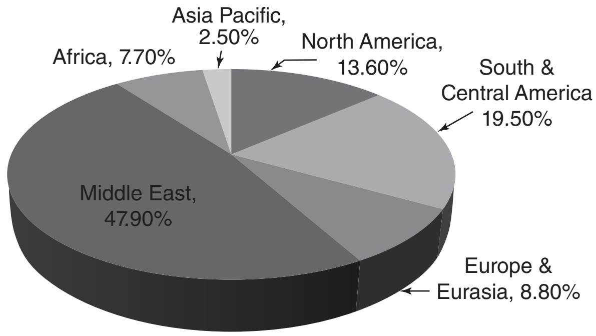

FIGURE 1.5 Distribution of oil reserves by region at the end of 2013; total proved reserves accounted for 1687.9 billion barrels
Source: BP Statistical Review of World Energy 2014.

Long-Term Supply and Demand

To understand the long-term demand and supply in commodity markets, let us take a look at a few of the indicators that are used.

Production and Reserves The supply of crude oil can be gauged by the production of crude oil (measured in millions of barrels per day), the amount of reserves of crude oil, specifically proved reserves (Figure 1.5), and the ratio of reserves to production (Figure 1.6), which gives an estimate of the number of years that the reserves can be expected to last. As expected, when the production of crude oil is high, prices are generally lower, although in general supply growth has tended to lag demand growth, leading to a gradually rising average price over the last two decades.

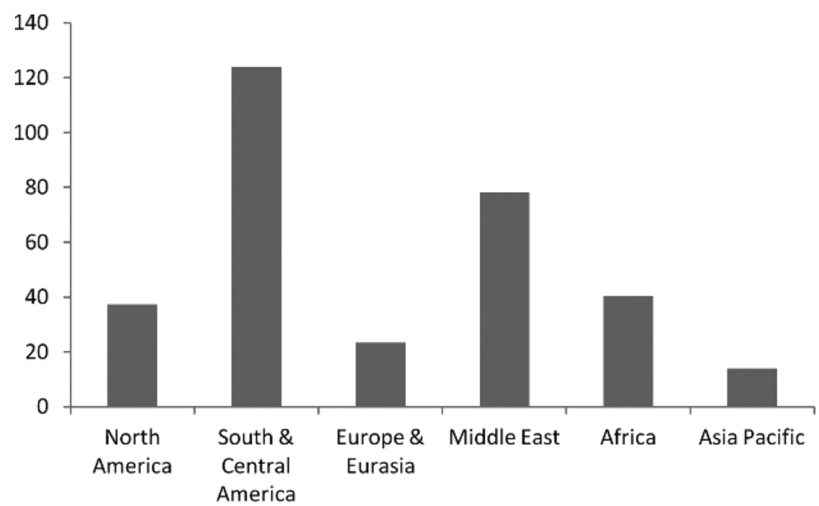

FIGURE 1.6 Reserves-to-production (R/P) ratios by region at the end of 2013
Source: BP Statistical Review of World Energy 2014.

Long-term prices are affected by the amount of reserves remaining. Proved reserves of oil (also called "1P") are those reserves that can be recovered in the future from known reservoirs with reasonable certainty (usually 90% confidence) under present-day economic and operating conditions. Probable reserves correspond to a 50% confidence level of recovery (called "2P" or proved plus probable), and possible reserves are those that have a less likely chance of being recovered (at least a 10% chance) and are called "3P" (proved + probable + possible). Disclosures regarding reserves can be affected by local accounting rules and whether the company reporting the figures is private or public. Since a number of national oil companies are private, the reserve numbers reported by them do not have the same level of scrutiny.

Reserve growth predictions are also affected by developments in technology. For instance, prior to the large-scale commercialization of hydraulic fracturing ("fracking") technology to exploit shale oil reserves and other technological innovations of the last decade, it was widely believed that oil would turn expensive. This was because oil production in the USA had peaked in the early 1970s (known as Hubbert's peak after M. King Hubbert, a US geologist) and the world's production was expected to peak in 1995. However, the introduction of new technologies and the increased viability of developing more difficult-to-extract reserves, such as oil sands, with higher prices of crude oil have combined to allow oil production to continue to grow.

In addition, in recent years there has been a discussion on reviewing the reserves of companies to account for "unburnable reserves" arising from the fact that it would be impossible to utilize some of the reserves if global warming targets are to be met. Similarly, carbon capture and storage (CCS) technologies would need to be developed before all the disclosed hydrocarbon reserves could be tapped. However, it is not yet clear if there is an appreciable impact of this concern on oil prices or the stock prices of energy companies.

Refining and Consumption Refining capacity is an indicator of the maximum supply of oil products. Demand can be gauged from the consumption of crude oil and the consumption of individual refined products. Refinery throughput or capacity utilization is another measure of the demand for refined products. Data on imports and exports, as in Figure 1.7, can also

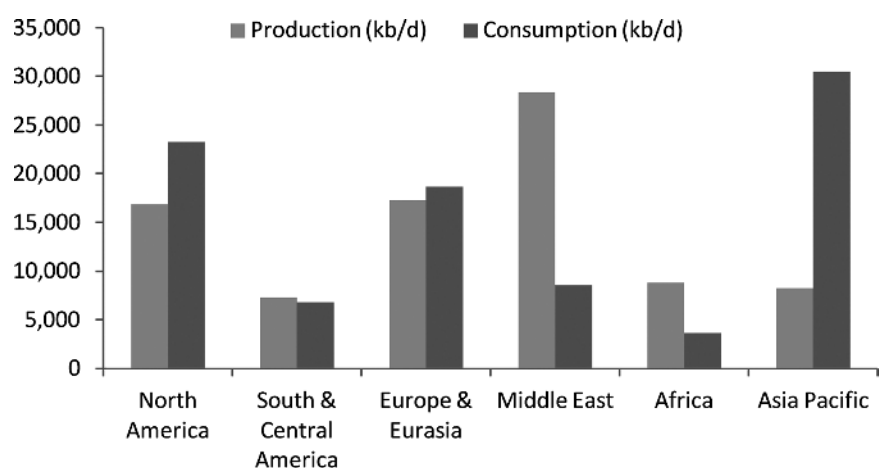

FIGURE 1.7 Oil production and consumption by region
Source: BP Statistical Review of World Energy 2014.

provide clues about the geographical distribution of demand and supply as well as the energy security of individual countries or regions.

Trends in Economic Activity The pace of economic activity is a good barometer of commodity consumption. An acceleration in GDP growth rate leads to higher usage of crude oil and other commodities, leading to higher prices during the uptrend in the economic cycle. Conversely, a contraction in economic output can lead to a sharp fall in commodity prices, as evidenced in the fall of 2008–09, when oil prices dropped from their highs of over 140$/bbl to lows of below 40$/bbl.

Technological Advances Technological advances affect expectations of long-term supply and demand. For example, rising oil prices make it viable to develop more producing assets, thus increasing future reserves and production. However, rising oil prices also spur investment in alternative energy sources and shape future demand as well. For example, the development of hydroelectric, solar, wind, and other forms of energy generation, the growth in the usage of biofuels and compressed natural gas (CNG) for transportation, as well as heightened public awareness and demand for electric-powered vehicles and hybrids are all consequences of higher oil prices. The environmental impact of using oil can also be credited with the development of tougher standards on emissions, reducing energy intensity of new technologies, and increasing investments in alternative energy.

Short-Term Supply and Demand: Supply Chain and Infrastructure

Short-term supply and demand are affected by disruptions in the supply chain of the commodity. For example, the hurricanes Katrina and Rita led to a drop of over 1 million bbl/day in crude oil output from the Gulf of Mexico and refined product capacity was significantly reduced (by a third of national capacity at one point). Maintenance of oil rigs and other equipment can also lead to short-term price dislocations.

Upstream Upstream production capacity and spare capacity affect prices as well. The amount of spare capacity maintained by OPEC, especially Saudi Arabia, has an effect on containing price rises. OPEC is an international organization, which aims to coordinate the petroleum policies of member countries and ensure the stabilization of oil markets. Its members, as of mid-2015, are the states of Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela. OPEC accounts for over 81% of the world's crude oil reserves as of 2012, and produces about a third of global production, thereby wielding significant influence over oil prices.

Refining Prices of crude oil are also affected by their usability in refineries and refining capacity. As refineries are large installations, which are constructed over a long period of time, refining capacity is finite and inelastic and refineries are typically configured to handle a specific type of crude oil. Thus, price trends for crude oil will be affected by the refining capacity available to process that particular blend of oil. For example, if it is more profitable to refine heavy crude oil in a complex refinery (vs. light crude oil), complex refineries will run at full capacity, reducing the premium for light crude oil. The development of complex refineries in Asia has served to increase the value of heavy, sour crude oils such as Dubai and Saudi Arabian crudes.

The difference in price between crude oil and the products that it can be converted to is called the crack spread or refinery margin. Short-term price movements of crude oil are affected by the margins that refiners can make on processing a particular blend of crude. Quality and yield differences can explain some of the differences in price between different crude oils.

Storage and Transportation Storage capacity helps to smooth supply and stabilize prices. The USA has a strategic petroleum reserve (SPR), which can be used to manage short-term price spikes due to supply disruptions. However, storage capacity can also explain some short-term price movements. For instance, if storage is full, prices will be depressed and oil producers have to reduce production. Conversely, cheaper storage would provide producers and traders with the option to store oil in order to sell in the future at potentially higher prices.

Transportation infrastructure and capacity helps to connect global prices and can influence the price of one blend of crude oil relative to others. Spreads between similar blends of crude oil can be explained to some extent by wet freight rates. For instance, the spread between Brent Crude Oil and Dubai Crude Oil reflects the relative supply/demand balance in Europe vs. Asia Pacific as well as the cost of shipping between the two delivery locations. Wider spreads can result in traders deploying vessels to deliver crude oil to the more profitable location, thus narrowing the arbitrage (the riskless profit that can be generated after costs). However, regulation can cause this relationship to break down in some cases.

Regulations Taxation and regulations also play a major role in determining crude oil prices. For example, until recently, crude oil could not be exported from the USA by law, while crude oil can be freely exported from other countries. With the rise in domestic production of crude oil from shale formations in the USA, the local benchmark of WTI Crude Oil has been dislocated from global crude prices over the last few years (Figure 1.8). Traditionally, WTI has traded at a slight premium to global benchmarks like Brent, but the addition of supply from

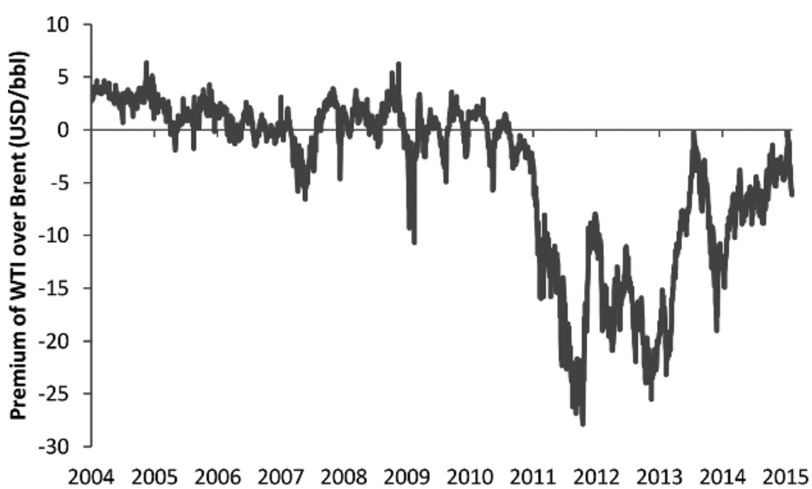

FIGURE 1.8 WTI Crude Oil premium over Brent Crude Oil (front-month prices)
Source: NYMEX, ICE, Bloomberg.

shale oil and Canadian oil sands, coupled with the inability to export crude oil, has caused WTI to trade at a significant discount to international crude oil prices in recent years.

Transportation mix and demand react to taxes on refined products, with customers opting for cheaper fuels such as diesel and electric power when tax rebates are offered. Environmental regulations also impose costs on industries for compliance with norms, requiring continued investment by both car manufacturers and refiners.

Financialization of Commodities

Over the last two decades, with the re-emergence of commodity futures markets, banks and other financial institutions have been participating in the commodity markets as well. As commodity futures are easier to manage than physical commodity inventory, speculators who wish to profit from changes in commodity prices are drawn to the futures markets. In many commodities, the benchmark prices are derived from these derivative markets as opposed to spot markets.

Commodities have shown zero or negative correlation with other asset classes like stocks and bonds over the period from 1959 to 2004. They have also shown significant correlation with inflation, indicating that commodities may be a better hedge against inflation than stocks or bonds. From the early 2000s, this diversification benefit of commodities led to a sharp increase in funds allocated to commodities as an asset class, especially via the commodity index and exchange-traded fund (ETF) route. However, over the last decade, the correlation of commodities with other asset classes has increased. Also, within commodities, non-energy commodities have become increasingly correlated with oil prices. Between 2004 and 2008, correlation between returns on major commodities with crude oil rose from around 0 to 0.5. Volatility also spilled over from oil and other asset classes to non-energy commodities, increasing the volatility of commodity prices as a whole.

Since commodities are denominated and settled mainly in US dollars, commodity prices are also affected by US dollar strength. After the financial crisis, the policies of quantitative easing pursued by the Federal Reserve and other central banks across the world have resulted in a high degree of liquidity for financial assets, which has spilled over into commodities as well, inflating commodity prices as the US dollar weakens. A reversal of these policies would see commodity prices retreating.

Market-Specific Price Drivers

Markets for other energy commodities like natural gas and coal have their own peculiarities. While they correlate well with oil markets in terms of financialization and regulations, supply/demand balances are more often calculated regionally than on a global basis, as these markets are considerably less integrated than global oil markets. A short summary of the factors affecting pricing in the natural gas and coal markets is presented here.

Natural Gas Natural gas markets are localized and fragmented due to the inability to transport gas cheaply in the absence of pipelines. LNG terminal infrastructure is also sparse in many parts of the world, and this has led to the use of multiple pricing mechanisms and regional benchmarks for natural gas. Traditionally, natural gas contracts have been of a long-term nature, with gas prices linked to prevailing oil prices by a formula – this practice is known as oil indexation or oil price escalation. Thus, natural gas pricing depends not only on long-term supply vs. demand, but also on developments in other markets like crude oil or power generation. Natural gas prices and power prices are closely linked, and both prices are regulated in many countries. However, with the growth in pipeline infrastructure, natural gas is increasingly being transacted based on benchmark prices, adjusted for location basis. The prominent benchmarks for natural gas are Henry Hub Natural Gas in the USA, the National Balancing Point (NBP) in the UK, and Zeebrugge and TTF (Title Transfer Facility) in Continental Europe. While Henry Hub is a physical hub for the pipeline system, NBP and many other European hubs are virtual hubs for trading. Using prices determined from trading at a hub, where supply and demand interact, to set contract prices is known as gas-on-gas competition and is currently the most common pricing mechanism for natural gas. Oil price escalation is still a significant pricing method, especially in the Asia Pacific region where there are no established price benchmarks for natural gas.

Coal Coal pricing is largely driven by the demand for electricity and the cost of labor and transportation of coal from mines to power plants. Since natural gas is a substitute fuel used for power generation, gas prices also affect the pricing of coal. Additionally, as the mining cost is only a fraction of the total price of coal paid by the final customer, and logistics account for a significant portion of the cost, the freight market also influences coal prices, and traders who deal with logistics are a large part of the coal market. Logistics providers are involved in moving coal from mines to ports, shipping in bulk to destination ports and splitting cargos and delivering them to final customers like power plants and industrial consumers, thus playing a major role in setting physical premiums for delivery. Traders have also served to reduce the credit risk inherent in long-term physical contracts between producers and consumers and provide financing for shipments.

Trading companies have been able to play a major role in coal markets due to the development of liquid coal price benchmarks. The most traded benchmarks of thermal coal include API 2 coal delivered into northwest Europe – Amsterdam Rotterdam Antwerp (ARA), API 4 coal originating from Richards Bay, South Africa, and Newcastle coal from Australia. Increasingly, prices for coal delivered into China have also become important benchmarks as China's appetite for steam coal increases. These price indices are calculated by price providers like Argus, McCloskey, and globalCOAL, and are used in over-the-counter (OTC) financial and physical contracts.

SUMMARY

The US dollar-denominated trade system of energy commodities and the importance of energy security in the modern world have made energy reserves into particularly strategic assets. The vulnerabilities of energy supply chains have been laid bare over the last couple of decades, and emerging powers have been making efforts to mitigate risks through alternative methods of supply and trading. Heightened energy price volatility, combined with the significant energy component in the cost of goods and services, has pressured the finances of consumers and made fuel price risk management imperative.

In this chapter, we have provided an overview of commodities, the main energy commodities, their sources and uses, and the factors affecting the markets for these commodities. We have focused on crude oil and how it is refined into various petroleum products destined for different uses. The price of a refined product is influenced by the supply/demand balance for that product and supply chain-related factors like upstream prices as well as macroeconomic conditions, among others.

In the next chapter, we will take a closer look at the impact of fuel price movements on the financial health of major energy consumers, including airlines, shipping companies, refineries, power producers, and industrial consumers. The commonality of price drivers for crude oil and downstream products translates into a high correlation between the prices of crude oil and products, and this suggests opportunities for the use of traditional hedging mechanisms as well as techniques like proxy hedging in risk management. We will also introduce the rationale for hedging, the basic market structure, and common instruments used for risk management in the fuel markets.