INTERNATIONAL ENERGY MARKETS

UNDERSTANDING PRICING, POLICIES, AND PROFITS

2ND EDITION

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PennWell®

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Note: An online glossary for this text can be found at http://dahl.mines.edu/glossary.pdf.

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Energy Lessons from the Past and Modeling the Future

Those who cannot remember the past are condemned to repeat it.

—George Santayana

Introduction

Energy markets continually evolve. How they evolve in the future will be influenced by many of the factors that we will discuss in this book, including energy resources, technology, population growth, demographics, climate change, costs, preferences, government policy, regulation, and risk. In this chapter, we will consider energy in the great historical panorama, which sets the stage for coming chapters. We will also consider models that help us forecast coming events, analyze policies, make business decisions, and simulate interactions between energy and other sectors.

Energy Geological History

Science suggests that the most cataclysmic energy event for the universe was at its beginning, with the big bang and subsequent inflation of the universe some 14 billion years ago (NASA 2013). These and other geological energy milestones are shown in table 2–1.

Although there is not total agreement or understanding of how the universe began, physicists generally believe it to have proceeded as follows. Before the big bang, time, space, matter, and energy did not exist. Then an anomaly caused negative gravity and positive energy to form from nothing. The net energy was zero, but the universe had zero size and infinite temperature. The negative gravity caused an expansion, and the high temperatures caused the formation of a small amount of matter in the form of subatomic particles from energy according to Einstein's $E = mc^2$. With the expansion, temperatures started to drop.

Dates	Era or Event
1901	Using the first rotary drill, Spindletop was discovered in East Texas.
1903	Wright brothers completed the first airplane flight powered by gasoline engine.
1908	Anglo Persian struck first oil in Persia.
1911	US government broke up Standard Oil.
1928	"Red Line" and "As Is" agreements limited international oil company competition.
1938	Mexico nationalized its oil industry; oil was discovered in Saudi Arabia and Kuwait.
1948	Jersey Standard (Exxon), Socony Vacuum (Mobil), California Standard (Chevron), and Texaco formed the Arabian American Oil Company (Aramco).
1951	Iran nationalized Anglo Persion Oil into the National Iranian Oil Company (NIOC).
1954	Western companies took over NIOC in Iran after the previous year's coup.
1959	Groningen gas field found in the Netherlands.
1960	OPEC was formed in response to cut in posted prices that reduced their tax revenue.
1968	Prudhoe Bay oil field was discovered in Alaska.
1969	Oil was discovered in the North Sea.
1970	US oil production peaked.
1971–79	Increased government participation and/or nationalizations occurred in OPEC countries (e.g., Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, Iran, and Iraq).
1973	Arab oil embargo of United States and the Netherlands began as result of Yom Kippur War.
	United States dismantled price controls implemented in 1971 as part of a price stabilization policy, but crude oil, oil product, and natural gas price controls were not lifted.
1974	International Energy Agency (IEA) was formed.
1975	Brazil implemented an ethanol program designed to eliminate fossil fuels in vehicles.
	United States authorized the Strategic Petroleum Reserve (SPR) and removed price controls on old oil.
1978	US Natural Gas Policy Act started natural gas price decontrol.
1979	Energy crisis resulted from the Iranian Revolution and oil production cuts. Iran renationalized NIOC.
1980	United States enacted windfall profit tax on crude oil.
1981	US domestic oil price controls were lifted.
1984	OPEC first established production quotas.
1985–86	Oil price plummeted more than 50% with Saudi Arabian netback pricing and increased production.
1991	Gulf War ousted Iraq from Kuwait.
1997	Qatar started exporting from world's largest LNG facility.
1997–98	Asian financial crisis caused oil prices to plummet.
1998	Landlocked Caspian Sea area became exploration hot spot, with export pipelines built in the following decade.
1999–2006	Oil company acquisitions and mergers: BP/Amoco; Exxon/Mobil; TotalFina/Elf; Repsol/YPF; Norsk Hydro/Saga; Chevron/Texaco; Conoco/Phillips; and Rosneft/Yukos.
2004	World Bank agreed to new lending rules intended to prevent the funding of corrupt regimes with revenues from oil and natural gas projects.
2005–08	Shale gas production took off in the United States.
2006	Russia temporarily cut natural gas supplies to Ukraine over a pricing dispute, which caused continuing security concerns in Western Europe.

Growth rates of coal production have varied over time, as well. They averaged more than 4% per year on a global basis from 1860 to 1913. More than 45% of this output came from a rapidly industrializing United States, with annual average increases of 6.8% during this period. Then with a world war and a world recession, global coal production in 1938 had not regained its prewar level from 1913. World production increased more than fourfold from 1938 to 1990. However, during this time period, it never regained its pre-1913 growth rates except in the 1970s, when the oil crisis and surging oil prices caused industry and electric utilities to switch toward cheaper and politically safer coal. Falling consumption in the 1990s was followed by growth rates after 2000 of 4.7%, rivaling those of the heady years before 1913, when coal was king.

Fossil fuel markets are rarely dull. We can see this from coal prices, which have fluctuated rather dramatically, as shown by US coal prices since 1800 (fig. 3–3).

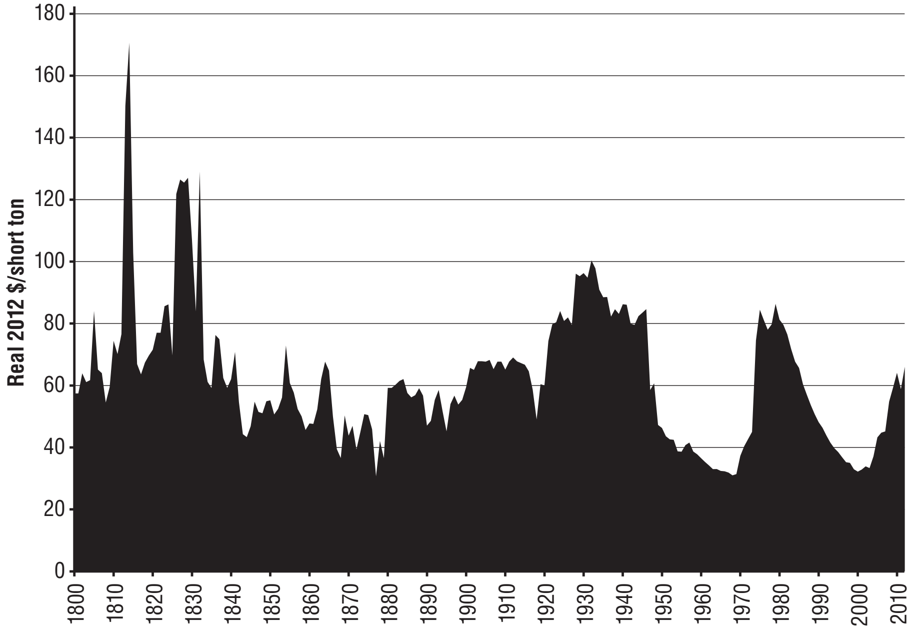

Fig. 3–3. US historical coal prices adjusted for inflation

Sources: The price variable is bituminous price deflated by the consumer price index. Price from 1949 to 2012 is from US EIA (n.d.b), which is extrapolated back to 1800 using the price of anthracite coal. Price of anthracite coal from 1800 to 1949 and consumer price index from 1800 to 1913 are from US DOC (1975). Consumer price index from 1913 to 2012 is from the US BLS (n.d.).

The price has been adjusted for inflation to real 2012 dollars. (See http://dahl.mines.edu/st03/st03.pdf, question 34, if you want to see how to use a price index to change nominal to real dollars.) It has averaged about $62 per short ton over the past 200 years. (Multiply by 1.1 to convert price to dollars per metric

Subsequent to 1979, US coal mine productivity has shown dramatic improvements, with production per miner-hour increasing. Production increased from 1.9 tons per minor hour in 1980 to average more than 5.5 tons per miner-hour in the most recent decade (US NMA, n.d.). (For an Excel model that can be used to simulate supply and demand models similar to the one above, as well as other models in this chapter, go to http://dahl.mines.edu/ch03m.xlsx.)

Demand and Supply Elasticities

Often we want to measure how responsive quantities demanded and supplied are to prices or other variables, or both, to help design energy plans and policy. For example, if coal demand in Asia is very responsive to income growth and income rises or falls sharply, there will be a large effect on the coal market. If coal demand and supply are very responsive to price, only a small change in price will be needed to bring about equilibrium after demand or supply shocks. Economists use elasticities to provide such a measure of responsiveness. The price elasticity of demand is the percentage change in quantity divided by the percentage change in price:

$$\varepsilon_d = \frac{\%\text{ change quantity}}{\%\text{ change in price}} = \frac{\Delta Q_d}{Q_d} \Big/ \frac{\Delta P_d}{P_d} \tag{3–7}$$

If the price elasticity is –0.5, and price goes up by 100%, quantity demanded falls by 50%. If the price change is very large, we often get a different elasticity depending on whether the price and quantity in the respective denominators are those before (P_{d1},Q_{d1}) or after (P_{d2},Q_{d2}) the price and quantity changes. So arc elasticities are typically defined using the average of the respective denominators as follows:

$$\varepsilon_d = \frac{\%\text{ change quantity}}{\%\text{ change in price}} = \frac{\dfrac{\Delta Q_d}{(Q_{d1} + Q_{d2})/2}}{\dfrac{\Delta P_d}{(P_{d1} + P_{d2})/2_d}} = \frac{\dfrac{(Q_{d2} - Q_{d1})}{(Q_{d1} + Q_{d2})/2}}{\dfrac{(P_{d2} - P_{d1})}{(P_{d1} + P_{d2})/2_d}} \tag{3–8}$$

It is often convenient to rewrite equation (3–7) as follows:

$$\varepsilon_d = \frac{\Delta Q_d}{\Delta P_d}\frac{P_d}{Q_d}$$

New Mexico					6%	15%
Severance Tax—Oil, Gas, & Uranium	7.09%	7.94%		3.50%		
Surface Coal			7%			
Underground Coal			3.75%			
West Virginia					4%	9%
Severance Tax—Oil & Gas	10.00%	10.00%				
Severance Tax—Coal			5.00%			
37–45 in. Seam Thickness			2.00%			
Less than 37 in. Seam Thickness			1.00%			

Sources: Kent and Eastham (2011); Temte (2010); New Mexico Taxation and Revenue Department (2013); Alaska Department of Revenue Tax Division (2013).
Note: See the Alaskan government tax return forms for more information on how the mining license tax varies with mining net incomes. The % symbol refers to an ad valorem tax. See individual state government tax forms for the most complete and updated severance tax information.