



# The Petroleum Revolution II: Concentrated Power and Concentrated Industries

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## 9.1 Introduction

In earlier chapters, we developed the link between the historical development of energy sources and the development of human society. More energy has allowed humans to do more work, including that of producing more wealth and more humans. We use the joule, for those not steeped in physical science, as the standard measure of energy. One joule is the amount of energy needed to accelerate a mass of 1 kg by a constant force of 1 Newton for a distance of 1 meter along a horizontal frictionless surface. A joule is equal to about one-quarter of a calorie. Our more familiar unit is the kilocalorie (often written as Calorie) and is found, for example, on the back of food packages. One kilocalorie is 1000 calories, equal to about 4 kJ. Thus, if you consume a drink that says it has 100 kilocalories, you will have consumed 418 kJ. Later, in ► Chap. 15, we explore the relation between energy and power from a scientific perspective. Power is the rate of doing work and is commonly measured in watts. From the standpoint of physics, *power* is energy used or expended per unit of time or the work that power causes or allows to be done. The most common unit of power is the watt, where  $1 \text{ W} = 1 \text{ J/s}$ .

But power means something else in a political and economic context, and here we want to extend the definition to ways in which power is used in the social sciences and day-to-day life more generally. English can be a difficult language for many people to learn because the same word, in this case power, can mean very different things. According to *The Oxford English Dictionary*, power means, in addition to the sense used in physics, the “possession of control or authority over others, or a movement to enhance the status or influence of a specified group, lifestyle, etc.” This definition seems equally appropriate to social realms, and this chapter reflects both perspectives—physical and social—on power. In most cases there is physical power behind any economic or social power. The latter cannot be measured as clearly and explicitly as can physical power, but all are clearly related. When the physical power to run an economy was solar, the economic and political power tended to be widely distributed in the hunting and gathering era. Then, after the Neolithic transition, land ownership became very concentrated in the hands of an aristocracy. People who owned land intercepted lots of solar power and tended to have a lot of

political power. The increased use of fossil fuels, which are concentrated energy, tends to concentrate both economic and political power in less area. Hence in the nineteenth and early part of the twentieth century, political power tended to pass from the landed gentry to those who owned factories in cities and then increasingly to those who owned the energy sources.

## 9.2 Petroleum and Economic Concentration

In ► Chap. 6 we developed the concept that control over energy and power, in the scientific sense, and led to increased output and an increase in status, wealth, and power in the social sense. The development of petroleum fuels allowed a previously unimaginable increase in the ability to do physical work as well as unheard of concentrations of economic power. This is true both for nations (in the United States throughout the last century, Britain and Germany during the previous century) and for corporations or individuals. There has never been, and probably never will be, an energy source as concentrated as petroleum, with the exception of fissionable elements such as uranium and plutonium. At the same time, there have been few, if any, industries as concentrated in the economic sense as “the old house” of Standard Oil. Concentrated economic and physical power emerged together in the United States and elsewhere. During the past century, many hundreds of small oil companies coalesced into the “seven sisters” that essentially controlled global exploration and production. The revolution in industrial structure and large monopolized firm occurred during the same historical time period and not merely by coincidence.

Economic concentration is synonymous with the process of monopolization. We use the term *monopoly* not in the narrow context of an industry that consists of a single seller, but in the broader meaning of an industry being dominated by a few very large companies. (The technical term for this is *oligopoly*.) In most of the developed world, monopolized or concentrated industry is neither rare nor an anomaly. This is true despite the textbook model of businesses favored by mainstream economists: competitive industries of many powerless firms operating in impersonal markets that allocate resources with

### 9.3 · Why Study Monopoly

maximum efficiency. Rather economic concentration is an explicit strategy on the part of firms themselves to control their economic environments and protect their opportunities to achieve profits in the long run [1]. The economic power controlled by a firm is regularly threatened by a host of internal and external forces: new products and markets, technological change, government regulation, and most importantly the rise of excess capacity and ruinous price competition. If a firm expands its productive capacity and then fails to sell the products, or can sell the products only at lower prices, its profits evaporate. The history of big business is largely the story of coping with excess capacity and avoiding price competition, often by getting favorable consideration by government. Perhaps no person stated the desperation business felt for a strategy to protect profits from price cutting better than nineteenth-century steel magnate Andrew Carnegie:

» Political economy says goods will not be produced at less than cost. This was true when Adam Smith wrote, but it is not quite true today... As manufacturing is carried on today, in enormous establishments with five or ten millions of dollars invested and with thousands of workers, it costs the manufacturer much less to run at a loss... than to check his production. Stoppage would be serious indeed. While continuing to produce may be costly, the manufacturer knows too well that stoppage would be ruin... Manufacturers have balanced their books year after year only to find their capital reduced at each successive balance... It is in soil thus prepared that anything promising relief is gladly welcomed. The manufacturers are in the position of patients that have tried in vain every doctor of the regular school for years, and are now liable to become the victim of any quack that appears. Combinations, syndicates, trusts—they are willing to try anything [2].

Initially Carnegie was of the mind that combinations of firms to control prices by controlling markets (i.e., monopolies) were folly. Carnegie Steel was a technologically dynamic company that could benefit from price cutting because it could outproduce all its rivals at a lower cost. Initially the company sought competitive advantage by cutting its prices, and buying up its weakened competitors, not through monopolies. Yet

Carnegie Steel would eventually become the core of “the steel trust” monopoly as US Steel (itself absorbed by the interests of banker J.P. Morgan). As we shall see, the same phenomenon of concentration by means of price cutting would characterize the largest trust of the era and the champion of the petroleum revolution—Standard Oil.

### 9.3 Why Study Monopoly

We believe that a new set of abstractions and economic theory must be developed for the second half of the age of oil. All theories of how the economy works commonly used today were developed in the age of rising oil availability and high energy returns on investment. Will these theories work in an age of declining availability of oil? To build a new theory, we need not abandon everything from the past. Rather we need to refine prior approaches and adapt them to a new era of biophysical constraints and limits to growth. But, more than anything, we need to begin this theoretical development from the perspective of understanding the economy as it actually exists, which is not simply a collection of small powerless companies who accept passively the impersonal forces of the market and forego large economic profit in the interests of low consumer prices and a stable general equilibrium. Rather the economy as it actually exists is dominated by giant corporations, operating on a national and international basis. These companies want to control market forces that threaten not only short-term profits but also their long-term growth in profits. These forces include ruinous price competition, rising costs of production, periodic recessions, excess capacity, unwelcome taxation and regulation, and the destabilizing effects of rapid technological change.

The study of the concentrated economy is important beyond the microeconomic level of the individual producer or consumer; the effects of monopolization are equally, if not more, important for the overall, or aggregate, macroeconomy. Some argue that a monopolized economy tends to stagnate rather than grow because of the internal dynamics of capital formation, as well as pricing and output decisions on the part of the large-scale firm in a concentrated industry. In simpler terms a concentrated economy cannot always create the growth needed to provide other laudable social goals such as full employment and poverty

reduction. The solutions to depression-borne problems of the nineteenth century, which often favored corporate concentration, have become the cause of different economic and social problems in the twentieth and twenty-first centuries. Market economies suffer from essentially two sets of limits. The first are the familiar set of internal limits revolving around the process of capital formation and investment, business cycles, and the uncertainties of competition with other firms. Strategies of industrial concentration first developed to transcend this set of limits. The second set of limits are generating an increased impact in the second half of the age of a suite of external, or biophysical, limits to growth as the raw materials necessary for the earlier strategy of growth become increasingly limited. Economics in the second half of the age of oil will require an understanding of the interaction of both the internal and biophysical limits to economic activity. In this new era continued high growth is highly unlikely because of biophysical constraints such as peak oil, declining EROI, climate change, and degradation of our oceans and soil fertility. Let us begin with the study of the petroleum revolution in the context of the ongoing decline in energy prices, concentration of economic power and the development of large-scale industry (■ Fig. 9.1).

#### 9.4 Petroleum and the Social Revolution

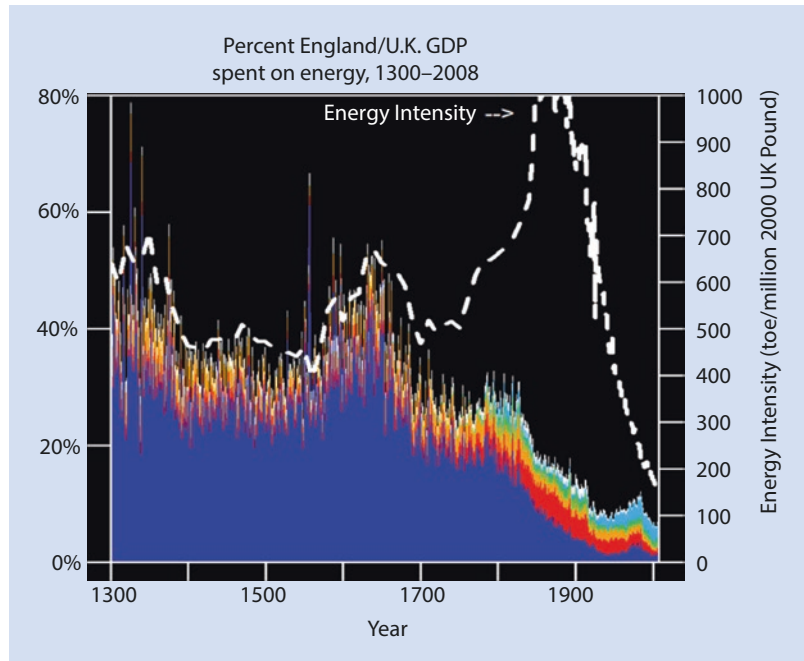
In 1850 the “civilized” world was illuminated at night principally by whale oil, which was undergoing its own peak and decline as species after species of whales were hunted to near extinction (■ Fig. 8.4e). By the late 1850s, kerosene was being refined regularly in Europe from crude oil obtained from hand-dug pits. The invention of a lamp with a glass chimney that would reduce the smoke and brighten the flame contributed greatly to the demand for kerosene. But kerosene could become “the new light” only if adequate and cheap supplies could be located. The limiting factor was the cost of hand-digging pits; the solution was to be found in well boring, soon to be known as drilling. The first commercially viable oil well in the United States was drilled by a promoter named Edwin Drake, given the appellation of “Colonel” by his supporting bankers to impress the rural population. Drake and his

drillers struck oil in August 1859 near Titusville, Pennsylvania. Within a year and a half of Drake’s successful well, another 75 wells were producing oil. Early successes created new boom towns such as Pithole and Oil City. Production in the oil regions of Pennsylvania soared from 300 barrels per day in 1859 to 3 million in 1861. As a result of the surge in supply, prices fell from \$10 per barrel in January of 1861 to 10 cents per barrel in June of 1861. Within a year demand expanded and oil prices rose again to over \$7 per barrel.

As we enter the second half of the age of oil, an age characterized by declining growth and declining energy returns on investment (EROI) for oil, and rising prices, one should not forget that the history of the first half of the age of oil was quite the opposite: increasing production, high EROIs, periodically plummeting prices, and overproduction. During the 1860s and 1870s, many small producers began to merge. This increasing monopoly concentration appears to have been a strategy to cope with the falling profits, prices, and bankruptcy caused by overproduction of an easily obtainable resource. Moreover, the legal basis of the new industry stemmed from the old English common law principle of the “rule of capture.” The petroleum beneath the ground belonged to the owner of the land above. But since the oil beneath was part of a common pool that could be depleted by a few, the incentive was to extract as much as possible as soon as possible in a process known as “flush production.” No place in the oil regions serves as a better example of the excesses of flush production and speculation than the town of Pithole, Pennsylvania. With the discovery of oil, property values soared, especially as oil production increased to over 6000 barrels per day. Derricks were erected on myriad tiny lots. Rapid extraction damaged the underlying strata, leaving a large share of the petroleum unextractable, due largely to the collapse of underground pressure. Property values and the town too collapsed.

Despite the demise of Pithole, production in the Pennsylvania oil region as a whole continued to increase, reaching 3.6 million barrels a year by the end of the Civil War. Given this much production, producers struggled to find adequate markets for the output, another problem that characterized the industry in its pre-peak years. Crude pipelines were constructed to avoid the bottlenecks imposed by poor roads

■ **Fig. 9.1** The price of energy as a percent of GDP for England 1300–2010. (Source: Carey King)



and recalcitrant teamsters, and the Titusville Oil Exchange opened in 1871 in an attempt to shorten the link between supply and demand. It was on this exchange that present structure of long-term contract prices, short-term “spot market” prices, and very long-term futures markets was established [3].

Once the chimney lantern became common in the United States, the expansion of demand for kerosene was largely a function of the general economic expansion and political stability that emerged at the end of the Civil War. This rise in economic activity affected many of the country’s primary industries and would be accompanied by an increase in the scale and scope of both manufacturing and transportation. The post-bellum period saw the creation of the national corporation, the expansion of long-lived fixed capital, and the replacement of the craftsperson operating on a local scale with semiskilled operative labor and centralized management. It was also the beginning of the nation’s dependency upon fossil fuels. The energy density of concentrated fuels combined with the new organization of labor produced dramatic increases in productivity and output. The new large-scale industry opened opportunities for large-scale businesses to control factors often left to chance in the older competitive economy.

## 9.5 The Rise of Standard Oil

No company is as closely associated with the concentration of economic power as Standard Oil. Standard Oil began modestly as a trading partnership in post-civil War Cleveland, Ohio, and rose to become the largest and most powerful company in the nation and the world’s first multinational corporation by the end of the nineteenth century. By the middle of the twentieth century, it was the largest corporation in the world. Standard Oil originally rose to power in the first stage of the petroleum revolution—the provision of kerosene for illumination.

The construction of a new rail line into Cleveland, Ohio, which had access to the Great Lakes and proximity to the Pennsylvania oil regions made Cleveland an ideal center for petroleum refining. By 1865 a young general merchant by the name of John David Rockefeller had become the largest refiner in the city. The refining industry was still competitive and the techniques of refining simple enough to preclude advanced technology as a barrier to entry. The result was a large number of small producers and intense price competition. As Rockefeller’s refining capacity grew, he realized he needed to find markets to absorb the output. To assure profitability Rockefeller developed a multipronged



strategy, centered upon the production of a high-quality product at a lower cost than his competitors. The very name Standard Oil stems from the quality of the company's kerosene. Standard Oil was able to control quality so that Standard's kerosene contained a negligible quantity of the dangerous by-product gasoline. Cost control was accomplished by a combination of large-scale production, reduction of transportation costs, and *vertical integration*, that is, amassing all stages of an industry from refining, to marketing, to transportation on an in-house basis. It was only later, when new oil fields were discovered, that Standard integrated backward into oil extraction.

The primary method Standard used to reduce transportation cost was the use of the railroad rebate, which was enabled by Standard's scale of production. Business historian Alfred Chandler reports that the first railroad, the Lake Shore running from Cleveland to New York City, willingly reduced transportation costs per barrel in 1872 from \$2.00 to \$1.35 in return for a guarantee that Standard would supply 60 carloads of oil per day to be transported. The increased output benefited the railroad as well as Standard by allowing a more consistent use of the railroad's capacity [4]. Standard then extended the policy of extracting rebates on the shipment of their oil to receiving a rebate, or drawback of 25 cents per barrel, on the shipment of their *competitor's* oil. According to energy analyst Daniel Yergin, "For what this practice really meant was that its competitors were, unknowingly, subsidizing Standard Oil. Few of its other business practices did as much to rouse public antipathy toward Standard Oil as these drawbacks—when eventually they became known" [3].

The problems of price instability, cost control, and capacity utilization, a regular feature of the industry since its inception, were exacerbated by the decline in overall economic activity following a financial panic in 1871 and the subsequent depression that lasted from 1873 to 1879. Chandler reports that the index of wholesale commodity prices, which stood at 151 in 1869, fell to 82 in 1886 [4]. Standard's production of refined kerosene continued to rise over the course of the 1870s, but its ability to market its product at a profitable price did not. Standard's strategy to address the threat of ruinous price competition was consolidation. In today's tech-

nical terms, this is called *horizontal integration* or the absorption of potential competitors for the purpose of controlling market price. Thus Standard undertook both vertical and horizontal integration and became increasingly the only game in town.

Merger was Standard's favored means of consolidation, and price cutting was its tactical method. Lower costs of production, made possible by economies of scale and cheaper transportation costs, allowed the company to undersell potential rivals. When faced with an independent producer that would not sell willingly, Standard subjected them to "a good sweating." They would increase output until the market price dropped below the rival's cost of production. Standard would then purchase the nearly bankrupt company at a favorable price and then restrict output so the price would once again climb. In the process, they brought the most able executives into Standard's management. By 1881 Standard controlled 90% of the kerosene market and sold 70% of its output in Europe. By the mid-1880s Standard's controlled 80% of marketing as well [4]. Despite the greatest degree of monopoly control that the nation has ever seen, the Standard alliance remained vulnerable to outside forces and reacted in a number of different ways to dissipate those threats and bring stability and control to the market for petroleum.

Price competition was not the only threat that faced Standard. Others included new sources of supply and new modes of transportation, as well as legal challenges. One threat was the attempt of independent producers to break Standard's hold of railroad transportation by building their own pipeline from the oil regions to the markets in the eastern United States. Standard then quietly acquired an interest in the Tidewater pipeline in 1879 and gained effective control of pipeline transportation within 2 years. Another problem was the discovery of fields outside of the Pennsylvania oil regions, first in Lima, Ohio. The additional production flooded the market and resulted in a price decline. After much debate, the Standard interests became directly involved in production, circumventing the oil exchanges. By 1891 Standard controlled approximately 25% of oil production. Standard had succeeded in building a truly integrated company, from extraction to refining and transportation to marketing [3].

By the mid-1890s Standard had become a fully consolidated and vertically integrated company. This form of business organization allowed Standard to withstand legal challenges to its strategy of price control by means of merging with competitors and fixing prices. Control over prices and ruinous competition was codified beyond a mere association of producers in 1882 when Standard formed the perfectly legal Standard Oil Trust. Stock shares of the various operating companies were ceded to Standard Oil of Ohio in return for trust certificates. Decisions about the direction of the company were made by a set of directors acting on behalf of the shareholders of the Standard Oil Trust rather than in the interests of the separate operating companies. While popular lore focuses upon price fixing, the first actions of the trust were to control costs. They reduced the number of refineries and concentrated production. Forty percent of output was produced by three refineries, and the average cost per gallon of refined oil fell from 1.5 cents to 0.5 cents. Standard expanded their marketing apparatus to assure adequate outlets for the newly expanded production, establishing wholly owned subsidiaries Continental Oil and Standard Oil of Kentucky as marketing companies [4]. Popular opinion and outrage led to the passage of the Sherman Antitrust Act in 1890, which banned conspiracies in restraint of trade. However, the Sherman Act was not intended to address the benefits of cost reduction by means of vertical integration, only price fixing due to horizontal integration. The cost cutting by expanding scale and controlling market allowed Standard to survive three significant challenges to become, by the mid-twentieth century, the largest and most profitable corporation in the world.

Beginning in the 1890s, several states filed suit against the Rockefeller interests, as well as against John D. Rockefeller himself. In 1907 the Federal government filed suit in the circuit court alleging that Standard Oil was in violation of the Sherman Antitrust Act. The circuit court found in favor of the government and Standard Oil appealed the case to the Supreme Court. In 1911 the Supreme Court validated the decision of the Federal Circuit Court: Standard Oil had conspired to restrain trade. The Standard Oil trust was dissolved into 34 separate operating companies, the most prominent being Standard Oil of New Jersey, Standard Oil of New York (Socony-Vacuum), and Standard Oil of California. Despite the breakup Standard of

New Jersey (later Exxon) remained the second largest industrial corporation in the country [4]. Jersey Standard is of particular interest. In an attempt to circumvent state-level legal challenges, popular opposition to the trust, and lackluster acceptance of the Certificates of Trust by financial markets, the company took advantage of holding company legislation, recently passed in New Jersey in 1889. The holding company legislation allowed manufacturing companies to purchase the stock of other corporations and issue its own securities for the acquisitions. The holding company replaced the trust as the legal vehicle for consolidation and merger and provided for even tighter control over the pricing and output decisions than did the trust. More effective and consolidated management was able to exert control over all phases of an operating company [5]. The Standard Oil Trust reincorporated in 1899 as a holding company: Standard Oil of New Jersey. Its capitalization increased from \$10 million to \$110 million, and it controlled the stock of 41 other companies [3].

## 9.6 Further Challenges to the Standard Empire

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A new legal form, vertical integration, and virtual control of the world market for kerosene did not insulate Standard Oil entirely from external threats to their control and profitability. They were to face new challenges at the twilight of the nineteenth century. These challenges came from new and substantial sources of supply, both foreign and domestic, new rivals to production and marketing. The new domestic sources of supply were discovered in Texas, Oklahoma, and California. Along with these discoveries came large and powerful new companies that are today as recognizable as is the name Standard: Texaco, Gulf, and Unocal. Other abundant sources of supply came into production in Russia, Romania, Indonesia, and, by the early 1900s, Persia. New international companies such as Royal Dutch Shell and BP were born of these discoveries. Another fundamental transformation of the petroleum industry occurred in this same period: the eclipse of kerosene by the electric light. Next another new innovation, the gasoline-powered automobile, would give vast new sources of growth and profit to the petroleum industry.

## 9.7 New Sources and New Rivals

Standard Oil initially satisfied domestic and world demand from its Pennsylvania oil fields. That was to change in the latter decades of the nineteenth century. The existence of oil on the shores of the Caspian Sea had been chronicled by Marco Polo. The first wells replaced hand-dug pits by 1872, and by 1873 some 20 small refineries were located in the Russian city of Baku. The industry expanded rapidly, from less than 600,000 barrels in 1874 to 23 million barrels in 1888, aided by the financing of the Nobel family. The Nobel Brothers Petroleum Producing Company was fully integrated, both backward into wells, tankers, and storage facilities and forward into refining and marketing. The demand for kerosene in Russia alone was insufficient to absorb the output of the Baku refineries. The short winter days and need for illumination could not overcome the poverty of the Russian peasantry. The Nobels success brought new competitors in the form of the Rothschilds, who purchased the railroad from Baku to the port of Batum on the Black Sea. Russian kerosene was now able to compete with that of Standard, which had previously controlled European markets. The American company then launched the type of price war that allowed them to consolidate their domestic empire. But the Russian-based companies fought back. The Nobels established a marketing company in the United Kingdom, while the Rothschilds improved technically the Baku-Batum railroad and eventually constructed a pipeline. By 1891 the Russian share of the world's kerosene exports rose to 29%, with a commensurate decline in US exports [3].

The Rothschilds, especially, were plagued with the age-old problem that characterized the industry in the first half of the age of oil: how to market the surplus resulting from the expanded production and refining of the new sources of supply. They turned their sights to East Asia and found an agent by the name of Marcus Samuel to sell their product to a wide network of merchants and traders. In the early 1890s, Samuel had developed the bulk tanker to reduce shipping costs and, by 1893, achieved access to the newly opened Suez Canal, cutting 4000 miles from the traditional route to Asia around the Cape of Good Hope. In the same year, Samuel founded a tank syndicate to reduce ruinous price competition in oil storage. By 1902 more than 90% of the oil transported through the

Suez Canal was under the control of Samuel's company, Shell Oil.

Another threat to Standard's control came after the discovery of oil on the Indonesian (then Dutch East Indies) island of Sumatra. In 1885 the first successful wells were completed, and production was concentrated under the auspices of the Royal Dutch Company in 1890. By 1892 Royal Dutch constructed a pipeline from the oil fields to coastal refineries, and by 1897 output had increased by five times from a mere 2 years earlier. Standard had previously marketed kerosene in Indonesia and considered Royal Dutch a threat which they desired to incorporate into the Standard operation. Instead, Standard was spurned, and negotiations commenced to amalgamate the company soon to be known as Royal Dutch Shell. The Asian producers and marketers wanted a greater degree of concentrated power to withstand what they perceived to be the immanent Standard tactic of price cutting [3]. The new company would survive to become one of the world's majors.

In addition to international challengers to its foreign markets, Standard was subject to declines in its domestic reach two decades before the Supreme Court ordered its dissolution in 1911. First, Pennsylvania-independent oil companies, united under the name of Pure Oil, constructed a pipeline to market their output on the east coast of the United States. Second, as early as 1885, it was clear that the output of Pennsylvania Fields had peaked and begun serious decline. The State Geologist of Pennsylvania stated that "the amazing exhibition of oil is only a temporary and vanishing phenomenon – one which young men will see come to its natural end" [6]. The oil boom of the entire Appalachian Basin was already over by 1900. Third, in the early 1890s, large fields were discovered in Southern California. By 1910 California's 73 million barrels represented 22% of the world's output, mostly controlled by the independent company Union Oil (now Unocal). Standard finally commenced operation in the California fields, establishing Standard Oil of California (now Chevron) in 1907. However, the monumental change in the oil business occurred in January 1901 with the discovery of the Spindletop field previously mentioned in ► Chap. 6. The original gusher produced 75,000 barrels per day and a new oil boom had begun. Land values skyrocketed and population soared from 10,000 to 50,000. In an experience similar to the one that occurred in the



Pennsylvania oil regions, numerous tiny leases led to more than 400 wells on Spindletop itself. Prices collapsed to 3 cents per barrel. The original promoters needed markets for their oil and found a likely buyer in Marcus Samuel's Shell Oil at a long-term price of 25 cents per barrel. The glut caused by the Spindletop find was augmented by another discovery in Oklahoma. The common problem of overproduction led not only to falling prices, but in this case, as in Pithole, flush production depleted the well. Underground pressure for Spindletop gave way in 1902, the year after discovery.

The stabilization of the Texas industry would fall to the Pittsburgh bankers (the Mellons) who had financed the initial operation. The original promoters were dismissed, the contract with Shell renegotiated, and the Mellons began the development of a vertically integrated company based on the extraction and refining of petroleum. Their first task was to come to terms with the overcapacity that the construction of the new refinery and pipeline network created. The corporation that restructured and further integrated into nationwide marketing became known as Gulf Oil. In addition, another significant corporation, Texaco, was built upon the expansion of transportation, storage, refinery capacity, and the currying of important political connections.

Every discovery would bring a glut of new oil and price declines into the market. This, in turn, created the need for constant expansion into new markets. Standard's control of the industry was clearly in decline. In 1880 Standard controlled 90% of kerosene refining in the country. By 1911, the year of its dissolution, the former monopoly controlled but 65% of domestic kerosene output, while its international markets likewise declined in the face of new discoveries and new competitors [3]. Yet while Standard's control was declining, its profits and output increased. The new century was to bring the end of the kerosene era but the dramatic expansion of oil demand as we entered the age of the internal combustion engine and the automobile.

## 9.8 Markets Lost and Markets Found

As we have said, the primary use of oil in the first stage of the petroleum revolution was for illumination purposes. The market for kerosene, however,

was to all but disappear at the end of the nineteenth century. In 1879 Thomas Edison perfected the incandescent light bulb and began operations of a generating plant in 1882. Edison made sure to price electricity competitively. Electricity overcame many of the drawbacks of kerosene such as smoke, soot, and oxygen use. But the adoption of electricity was not immediate. The original generating plants, located near load centers until the adoption of alternating current, were powered by coal-fired piston engines which were very noisy and dirty. Moreover, electricity was considered dangerous and the cause of myriad great fires that swept the urban centers of the Northeastern United States at the dawn of the twentieth century. While a young man, Klitgaard spent many years as a restoration carpenter and saw the reason. He observed and corrected many situations where electricity entered urban dwellings at 240 volts over bare wires, with only ceramic insulators separating the wires from the dry roof beams upon which they were placed. But once these safety constraints were overcome technically, the use of electricity for light and power caught on quickly. In the time period from 1885 to 1902, demand for light-bulbs soared from 250,000 to 18 million per year. In 1890 only 15% of urban railways and streetcars were powered by electricity. By 1902 94% used electricity as a motive force [4]. Problems with carbon emissions as greenhouse gases had barely been recognized theoretically. The switch to electrical power virtually eliminated the very serious public health problems associated with the use of horses as beasts of burden.

Electricity fundamentally changed the process of production. When factories were powered by a central source, steam, or water, the layout of the factory was dictated by distance from the central source, and power was delivered to places of use by dangerous and inefficient system of pulleys and belts. Factories had to be multistory affairs on a small footprint. Much time was lost to the movement of semifinished goods between floors. The advent of the electric motor allowed sprawling single-story sheds with the power source decentralized to the individual machine. Here again, we see the role of energy in the improvement of productivity. The same process of industrial concentration occurred in the electrical industry itself. In 1892 the New York Banker J.P. Morgan consolidated Edison Electric with Thompson-Houston to form General Electric which shared the market

only with Westinghouse. In the type of co-respective behavior common to oligopolies, Westinghouse and GE regularly shared patents [5].

## 9.9 The Age of Gasoline

In the first phase of the petroleum revolution, gasoline was a dangerous by-product. But gasoline becomes the primary petroleum product with the invention of the automobile powered by the internal combustion gasoline engine. Automobiles gained acceptance in Europe by 1895 and soon after began to sweep personal transportation in the United States. Eight thousand cars were registered in 1900. By 1912 nearly a million vehicles were on the road [3]. One year later Ford took advantage of the possibilities afforded by the electric motor and single-story shed production when he built his first assembly line in Highland Park, Michigan. In the early days of the industry, autos had been assembled by teams of skilled workers, often bicycle mechanics, who built each car from the wheels up. Automobiles were little more than luxury items for the affluent. Ford's Model T, introduced in 1908, sold for \$850, then an enormous sum. After the construction of the Highland Park, plant cars were assembled by semiskilled operatives on a continuous line. The price of a Model T fell as the cost of production fell with the expansion of scale and an increase in the throughput of materials and labor. By 1925, the peak of the first automobile boom, a Model T sold for \$240. Mass production changed the automobile from a luxury item to one that workers could afford. Ford workers were paid above the industry average. Ford nearly doubled industry standard wages when he commenced his famous "\$5 day" in 1915, essentially as a cost-saving measure. Previously assembly line work was seen as so degrading that the Ford plants had a difficult time retaining an adequate workforce. Absenteeism was 10.5% and turnover reached 470% in 1913. Turnover costs in 1913 alone were nearly \$2 million. So Ford raised wages to keep his workers. "There was...no charity involved... We wanted to pay these wages so that business would be on a lasting foundation. We were building for the future. A low wage business is always insecure. The payment of \$5 for an 8-hour day was one of the finest cost-cutting moves we ever made" (Ford, quoted in Perelman 2006: 135) [7].

As the price declined, and credit was offered, sales and registrations of automobiles increased steadily, reaching 23 million in 1925. Registrations fell during the depression, and new cars were not produced during the Second World War, as auto plants were converted to produce tanks and airplanes. Moreover, gasoline and tires were rationed during the war. The second automobile boom commenced following the war and produced lasting impacts upon the nation. In 1950, 40 million cars were registered in the United States. This figure climbed to over 65 million in 1962 and more than 250 million by 2007.

The automobile qualifies as what economists call an *epoch-making innovation*. Few other such technological changes qualify. An epoch-making innovation must not only absorb large amounts of capital investment, but must create more opportunities for investment in other industries. Baran and Sweezy contend that only three innovations transformed society, absorbed sufficient capital, and created new industries and processes: the steam engine, the railroad, and the automobile. To this Richard Duboff adds electrification and Michael Perelman contends that computerization must be considered [5, 7, 8]. The automobile not only absorbed tremendous amounts of fixed capital, accounting for 6.3% of all value added in manufacturing in 1929, but also created myriad peripheral industries. Repair shops, drive-in movies, motels, gas stations, and the fast-food industry owe their existence to the automobile. The automobile itself is dependent upon petroleum for energy. Indeed all epoch-making innovations have been energy-intensive, indeed among the most energy-intensive products of their day. Moreover, these innovations have been subject to a similar degree of industrial concentration as was the petroleum industry, largely for the same reasons: the need to rationalize production, reduce costs, expand market share, and avoid ruinous price competition.

## 9.10 Industrial Concentration as a Consequence of Concentrated Energy

Before the massive use of fossil fuels, production was essentially organized on the basis of small shops using skilled labor. Skilled master craftspeople were generally responsible for all or many stages

of production and agreed to be responsible for the training of apprentices. Upon completion of their apprenticeships, new craft workers were deemed fit by the society of masters to travel to obtain independent unsupervised work. In fact they were called journeymen. After a long period of learning the technical and business skills of their respective trades journeymen could rise to the rank of master. Societies of masters, which were called guilds, decided collectively upon prices and standards of quality. This world of small business did not display the type of price competition found in microeconomics texts. As an institutional structure, guilds limited the type of competition that could ruin a master's fortune. Instead the guilds brought stability to the preindustrial economy. Thus, the modern concept that competition is necessary for efficient operation of businesses was not the historical norm.

Few examples existed of alternative organizations. Large-scale textile mills appeared along the swiftly flowing rivers of New England at locations such as Lowell and Lawrence, Massachusetts, and Manchester, New Hampshire, by the 1820s. These mills not only employed larger numbers of workers than the typical small shop, but they were not organized around the principle that every entry-level worker would become eventually a master. The labor force of the early textile mills consisted mostly of young women recruited from the hard-scrabble New England farms, whose employment, frequently boring and arduous, was expected to be temporary.

In the decades after the Civil War, the US economy went through a process that economic historian Richard DuBoff termed “the grand traverse” and what we call industrialization or the development of the hydrocarbon economy. This transition entailed the transformation of a primarily local and regional economy utilizing local natural sources of energy into an economy that was based on large-scale industry, mass production, and the use of fossil energy, generally derived from far away. The railroads were the nation's first big business. Railroad building commenced in earnest in the late 1840s, following the nation's first depression. There were only about 2300 miles of track when the decade of the 1840s began. Another 5100 miles of track were added in the 1840s and 21,400 in the 1850s. After the Civil War, track building increased significantly. In the 1880s additions to track construction peaked, when another 74,700 miles were built. By the time rail-

road travel was supplanted by the automobile and freight was hauled primarily by truck, the railroads had established themselves as the nation's first large-scale enterprise. Railroads accounted for 15% of all gross private domestic investment in the 1850s and 18% in the 1870s and 1880s [10]. Moreover railroads augmented the communications networks, as telegraph wires were built along railroad rights-of-way. The construction of a viable transportation and communications infrastructure was vital for the transformation of the economy as a whole. Recall how Standard consolidated its hold on refining by achieving lower-cost transportation by means of an existing railroad network. The ability to manage a nationwide market was greatly enhanced by a functioning transportation and communications infrastructure.

The economy was transformed fundamentally in the years following the Great Depression of the 1870s as industrialization increased more and more. Not only did the scale of production increase, but so did the organization of labor. As in the case of Standard Oil, the control of costs became a fundamental element in the competition between large enterprises. Jobs were subdivided in a way that Adam Smith himself could barely imagine. The essence of competition became based on increasing productivity. Craft workers were supplanted in manufacturing by an immigrant force of unskilled and semiskilled labor who were content with boring repetitive piecework for secure wages. Behind the ability to mechanize, transport, and impose the detail division of labor was the access to cheap energy. Business historian Alfred Chandler states the matter succinctly: “Cheap coal permitted the building of large steam-driven factories close to commercial centers and existing pools of labor. In the heat-using industries the factory quickly replaced the artisan and the craftsman... Coal, then, provided the source of energy that made it possible for the factory to replace the artisan, the small mill owners, and the putting-out system as the basic unit of production in many American industries” [4].

## 9.11 Threats and Opportunities

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Chandler also makes the important point that the revolution in transportation, itself based upon cheap energy, further transformed the distribution of products. The modern corporation was

not born with the advent of mass production but rather necessitated the unification of mass production with mass distribution. If a company produces more than it can sell, the incentive to produce even more output or invest in capital equipment declines. This will be a theme that recurs through subsequent years of economic development. Capital accumulation, brought about by investment in capital goods, is the engine of growth in a private enterprise economy. Periods of lagging investment bring about economic downturns, and the low-profit potentials of a sluggish economy further reduce the ability to find profitable outlets for one's investment capital. The percentage of net national product (or gross national product minus depreciation) that went into investments climbed steadily over the course of the nineteenth century from 10% in the 1840s to 18% in the 1870s to 20% in the 1890s [5]. This growing level of investment aggravated the problems that can occur from producing more than can be consumed. As Andrew Carnegie had realized, large-scale companies would attempt any alternative to shutting down; the consequence of walking away from the considerable costs embodied in the capital equipment was unthinkable. The costs sunk into the purchase of capital equipment typically drove most company leaders to concentrate in order to protect their capital investments from price competition.

Various forms of economic concentration, such as vertical integration, horizontal integration, trusts, and holding companies, were responses to a number of chronic problems that plagued American enterprises operating in the new world of expanding markets, rapid technological change, financial uncertainty, and the availability of cheap energy. Concentrated fuels certainly opened up vistas of low-cost production and transportation unheard of before the harnessing of fossil fuels, but cheap energy alone was insufficient to protect producers from a set of internal limits to capital accumulation such as the tendency to produce too much to sell at a profit. Viewed in this light, monopoly is not a minor aberration to an otherwise competitive economy. Rather it is the eventual outcome of a competitive process as companies attempt to control their economic environment and protect profits and potential growth by avoiding the type of competitive behavior that could perhaps ruin them. In

essence, the history of the American industrial revolution is the history of both cheap energy and monopoly concentration and is understood best as a combination of these factors.

Thus economic concentration emerged not as a mistake in the competitive process, as today's mainstream microeconomic theory would have us believe, but as an explicit strategy.

Even as neoclassical economists were perfecting the elegant theory of the "perfect competition," industrialists such as Carnegie, Rockefeller, and other captains of the oil industry were decrying the ruinous effects of "cutthroat competition." For the theorist, price competition was necessary for their view of economic perfection. Resources flowed to their most lucrative use, while the market system forced competing firms to produce at the lowest possible cost and pass the savings onto consumers in the form of low prices. In the end the system balanced in a stable equilibrium. The only way to insure a perfectly competitive equilibrium, however, is to ignore the problem of fixed cost. In fact the initial assumption of the economists of no barriers to entry precludes the analysis of the cost of long-lived fixed productive assets. But industrialists operated in the real world where large-scale industry required substantial investment in fixed capital. If, at the same time, the cost of producing one more unit of output (what economists call marginal cost) is low, real-world producers face a dilemma: competition drove the market price down below the level at which industrialists could turn a profit or even recoup their fixed costs.

The standard economic theory of competition asserts that competition will bring prices down to the level of marginal cost. Theoretically entrepreneurs are willing to accept the going rate of normal profit as all else is competed away by rivals lowering their prices in order to capture more customers. Moreover, the system is stable and there is no tendency to change. But in the real world of business, managers who earned no profit and had no prospects for profit growth would quickly be out of a job. If a real-world industrialist borrowed money to purchase large-scale equipment and then finds prices competed down to the level of producing one more unit of output, the company would never be able to generate revenue sufficient to repay their bondholders and bankers. One may think of railroads, where most of the cost is in tracks and locomotives and little of the cost is in cheap fuel or

labor, or in the modern world airlines, for such real-world examples. Chandler summarized the position of the railroads when he said:

» “Competition between railroads bore little resemblance to competition between traditional small, independent unit commercial or industrial enterprises. Railroad competition presented an entirely new business phenomenon. Never before had a very small number of large enterprises competed for the same business. And never before had competitors been saddled with such high fixed costs. In the 1880s fixed costs, those costs that did not vary with the amount of traffic carried, average two-thirds of total cost. The relentless pressure of such costs quickly convinced the railroad managers that uncontrolled competition for through traffic would be ruinous... To railroad managers and investors, the logic of such competition appeared to be bankruptcy for all” [4].

## 9.12 The Loss of Worker Power and the Gain in Financial Power

Labor productivity continued to rise as the result of the prolonged investment boom and the increase in the energy subsidy to each worker [11]. Productivity growth averaged only 1.6% per year from 1889 to 1919. After the 1920–1921 recession until the late 1950s, it averaged 2.3% annually. New processes such as electrification increased industrial efficiency, and the new technologies of the automobile further reduced the costs of transportation. These innovations, of course, depended upon an ample supply of cheap fossil energy, much of it from the newly discovered sources in California, Texas, and Oklahoma. But consumer demand did not increase as rapidly as productivity or organizational innovations such as scientific management, resulting in wage growth that did not keep up with production. The lack of purchasing power combined with the ebbing of the investment boom, created the conditions underlying the Great Depression. Automobile sales peaked in 1925, the year before the peak in investment as a whole. Construction of skyscrapers in major eastern cities ground to a halt. The decline in demand for autos and skyscrapers reduced the demand for

steel, and declining demand for steel further reduced the demand for coal. In another blow to investment, a hurricane devastated South Florida, destroyed the railway through South Florida and the Keys promoted by John D. Rockefeller’s early partner, Henry Flagler, and brought a speculative boom in suburban housing to a close.

Yet even while the real economy was “softening,” the demand for financial securities continued to rise, fueled by margin buying. Investors could purchase a stock by putting up only a fraction of the value of the stock (the margin) and borrowing the remainder from their brokers. (This is called *leverage* today.) The volume of such loans (the broker’s call market), according to John Kenneth Galbraith, was the most accurate index of speculation, as it was money borrowed to purchase stocks, and not real assets. In the early 1920s, the volume of these loans was approximately one to one and a half billion dollars. By 1927 the market increased to a volume of three and one half billion. 1928 saw broker’s call loans increase to four billion and, by 1929, six billion dollars. With all this debt-fueled buying, stock prices registered impressive increases throughout the summer of 1929, enhancing the optimism of the market and increasing further the demand for call loans. But reports of the underlying weakness in the real economy began to sap the confidence of some knowledgeable investors throughout the fall of 1929. By October the markets were wavering, although the confidence of investment bankers remained high. Charles Mitchell of National City Bank believed that the underlying fundamentals of the economy were sound and that too much attention was being paid to broker’s call loans. Nothing, according to Mitchell, could arrest the upward trend [11].

## 9.13 The Great Crash

On October 29, 1929, the stock market collapsed. Stock values plummeted by \$26 billion. In relative terms, the stock market lost approximately one-third of its September value. The economy was soon plunged into depression. GNP declined by 12.6% from 1929 to 1930, and unemployment increased from 3.2% in 1929 to 8.7% in 1930, peaking at 24.9% in 1933. But how did this happen given that less than 2.5% of Americans owned stock? [12].



The answers lie partly in the weakness of America's banking system. Rural banks, in particular, were chronically undercapitalized without adequate funds to repay their depositors in case of an emergency. Most of their reserves had been loaned out already. More than 500 per year failed even in good economic times. However, the crisis of bank failures climbed after the stock market crash to include urban money center banks. After the collapse of the stock market, heavily leveraged investors could not repay their brokers who, in turn, could not repay the banks. An additional 1352 banks (above the normal 500) failed by the end of 1930. Policy decisions exacerbated the failure of the banking system as the Hoover administration tightened credit and raised interest rates, partly to punish speculators and partly to shore up the British Pound. Moreover, the international gold standard was rendered unworkable after the stock market crash and wave of bank failures. According to the dictates of the gold standard at the time, all trade deficits had to be paid in gold at the end of the year. But gold also functioned as the domestic currency. Squaring international accounts under the prevailing institutional arrangements meant reducing a nation's domestic money supply. This exacerbated the deflationary tendencies already touched off by the collapse of banks and financial markets. In addition, the Versailles Treaty ending First World War had imposed \$33 billion worth of reparations on Germany. Germans borrowed heavily from US banks to pay their reparations to England and France. England and France used the reparations payments to repay their loans to US banks. The collapse of the US banking system precluded more loans to Germany. Germany thereby defaulted on their reparations payments, and England and France suspended payments upon their war debts. The international trade system simply collapsed, hastening the reemergence of hostilities in a world shaken by long-term depression [12].

The world that emerged from the Great Depression and subsequent world war was a world fundamentally transformed. The ideology that markets would find their own efficient equilibria was dealt a near-fatal blow by the depth of the depression. The New Deal and Keynes' *General Theory of Employment, Interest, and Money* were to establish the role of government intervention into the economy. Commodity money in the form of the gold standard would give way to government-generated fiat money.

International oil supplies would remain in the hands of the allied powers, and oil would soon become officially denominated in US dollars, soon to become known as petrodollars. In short, the postwar social and economic order would soon become dominated by the United States as a political power, by the large-scale corporation as an economic power, and by petroleum as a source of energy and power. Power over the control of oil became political power over the rest of the world.

## 9.14 Conclusion

In the years following the Civil War, the American economy was transformed from a small-scale, regional endeavor based on skilled labor, hand tools, and natural sources of energy such as wood and grass into a large-scale, national economy powered by cheap fossil energy, long-lived fixed capital in the form of machines and factories utilizing deskilled operative labor. Long before the peak of US oil production, the economy experienced myriad periodic downturns, including three great depressions in the 1870s, the 1890s, and the 1930s. During these times, the pressure on the large-scale industries became intense, and many were driven toward bankruptcy by competitive price devaluations. Facing bankruptcies, the favored strategy was the concentration of industry by means of consolidation and merger. By the 1890s two merger movements had produced most of the characteristics of big business we recognize today, from a few firms controlling the majority of an industries output, to the rise of non-price competition, such as competing to reduce price and expand market share. Horizontal mergers were designed to eliminate ruinous price competition, and vertical integration reduced costs by bringing all aspects of production, distribution, and marketing within the control of a central management and creating the economies of scale. By the end of the century, these concentrated industries had devised mechanisms, such as trusts and holding companies, to cope with the chronic problems of overproduction and excess capacity that accompanied price competition [9].

The evolution of the large corporation and the concentrated industry was a fundamental part of the industrial revolution itself and was enabled and encouraged by the fossil fuel revolution. Many economic historians have chronicled the role that

the rise of monopoly concentration played in the American economic experience. Few, however, have focused on the role played by cheap energy. Since we believe that economics should be both a social and a biophysical science, it is important to link the development of energy and power as physical entities with the social and economic factors that they allowed and generated. We can achieve a better understanding how the economy works, historically as well as contemporaneously, by viewing the development of economic power in the context of power in the physical sense; national and corporate powers alike still work to consolidate economic strength just as military or political strength is often consolidated.

The economy still experiences a roller coaster of expansion followed by depression or recession despite the existence of dramatic technological change, the availability of cheap energy in the form of coal and then petroleum, economic concentration, and organizational innovation. Even in times of abundant cheap energy, such as the 1930s, the economy experienced downturn due to the internal dynamics of technology, investment, productivity, demand, and excess capacity. Historically this internal tendency is periodically reversed by the introduction of epoch-making innovations such as the steam engine, the railroads, electrification, and the automobile, allowing for the long-term expansion of productivity, investment, and economic growth. All of these innovations were energy-intensive and depended upon the availability of cheap energy. The digital revolution, energy intensive in its collective impact, may or may not qualify as a major epoch-making innovation, but it seems not to have resolved the problems inherent with the others, as the major economic downturns of 2001 and 2008 seem to indicate.

What is the fate of the concentrated economy as the age of cheap energy comes to an end? In other words, will the biophysical constraints combine with the already existing internal limits to bring about the end of the growth economy? What are the chances of another epoch-making innovation will usher in another buoyant era of economic growth? Can some kind of “green” energy do this? Could this take place while nearly every scientific measurement of the human impact upon the planet indicates we are already in overshoot? If we are already exceeding the biophysical limits of the planet, we doubt severely that we can grow our way into sustainability. But

economic growth is at the heart of a monopolized economy. How do we reconcile the need for living within our biophysical limits with the need to produce jobs and opportunity for the next generation and reduce poverty, all of which have relied on growth, at least historically? Much of the rest of the book will focus on that question.

### ? Questions

1. How did the emergence of the fossil fuel age result in a concentration of political and economic power?
2. What is an oligopoly?
3. What was the first large-scale use of petroleum? What resource was it replacing? Why?
4. What is vertical integration?
5. What is horizontal integration? How was it accomplished by Standard Oil?
6. We see kerosene replacing whale oil, and electricity replacing petroleum, both fairly rapidly. What do you think will replace electricity, if anything?
7. Why didn't the end of the kerosene age mean the end of Standard Oil?
8. What was Henry Ford's idea about guaranteeing sales for his Ford automobiles?
9. What is an epoch-making innovation? Can you give three examples and tell how each is related to energy, and do you believe there are any happening now?
10. What was the relation of the rise of coal to skilled labor?
11. Can you give several perspectives on the role of competition in the economy?
12. What was the objective of the Sherman Antitrust Act in 1890?
13. Do you think the basic business conditions of the early 1900s were very different from those of today? Why or why not?
14. “The ideology that markets would find their own efficient equilibria was dealt a near fatal blow by the depth of the 1930s depression. The New Deal and the *General Theory of Employment, Interest, and Money* established the role of government intervention in the economy, as well as a focus on the inability of the private sector alone to create sufficient overall demand to maintain full employment.” Discuss these two sentences in light of today's economy.

15. A general problem of industrial capitalism is that the economy is usually unable to absorb all that is produced by the very productive fossil-fueled economy. What were some of the approaches used in the 1950s to deal with this problem?
16. How might the end of cheap oil change the way that our industrial economy operates?

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