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state at the outset some of the limits of our inquiry as we have conceived it. The industrial field covered is indicated in Chapter II. It might be summarily described as the whole sequence of processes from exploration for oil to the delivery of refined petroleum products to consumers.

Within this field we have conceived it to be our responsibility not only to canvass the available statistical data upon current prices and costs (Chapter III), but also to examine critically the meaning, adequacy and reliability of these data and to suggest ways in which they might well be supplemented (Chapter IV). As we understand it, we were not called upon to make detailed investigations or tests of existing price information to verify our judgment of its character. Much less was it within our conception of the assignment to attempt the assembly of any concrete data not now available. Nor were we charged with making new applications of such data as we now have. In Chapter V we confine ourselves simply to outlining certain projects of inquiry which in our judgment should prove fruitful, and the more fruitful so far as the statistics of the industry's operations are made more adequate and reliable by supplementing existing compilations along the lines suggested in Chapter IV.

II

GENERAL CHARACTERISTICS OF THE PETROLEUM INDUSTRY AND ITS PRICE PROBLEMS

A FORMULATION of the economic and industrial problems centering in oil prices, toward the solution of which a research program might properly be directed, involves a preliminary consideration of the technical and economic characteristics of the productive processes by means of which crude oil in the ground is transformed into oil products in the hands of consumers. Such a consideration should be designed to reveal, or focus attention upon, those characteristics of the productive processes which reflect themselves in oil price problems or which give to oil price problems a distinctive quality tending to differentiate them from

price problems in general. A consideration of such special characteristics should be helpful in determining and delimiting the specific problems that afford a proper and feasible objective of price-cost study in the oil industry.

The limited and localized occurrence of crude petroleum, the fortuitous and unpredictable discovery of new deposits, the uncertainty of their extent, the exhaustibility of the resource, its variable and migratory character, the statutes, administrative regulations, and court decisions governing its recovery, the storability of the product, the specialized and fixed character of the investment in productive processes, the joint character of the production cost of its numerous refined products, the widespread distribution of the consumers of its major product, gasoline, the seasonal character of the demand for gasoline, the number of and differences between motor fuels, the lack of satisfactory substitutes—these characteristics or factors have their repercussions upon cost, prices, productive capacity and output and give to the industrial problems centering around price a peculiarity and perplexity that warrant special consideration.

EXPLORATION FOR, PRODUCTION AND STORAGE OF CRUDE PETROLEUM

Since oil in commercial quantities occurs in the voids and crevices of a great variety of geologic structures concealed at varying depths beneath the earth's surface, there is in its discovery a very large element of chance. Because of the elusive character of oil deposits and the fortuitous factors in oil finding, the search for oil has called into operation two types of activities—random and scientific. During the early years of oil exploration discoveries were primarily the result of random effort. As the demand for oil products expanded under the impact of modern methods of transportation, the services of geology and physics in their more recondite ramifications have been commandeered in the search for oil. Stratigraphy, micro-paleontology, seismography, magnetometry—all have been turned to practical

account in an endeavor to find likely oil structures. But as more precise methods have been resorted to, random activities have not been abandoned entirely and only through complementary recourse to two apparently incompatible procedures has oil been brought into the market in amounts adequate to meet a persistently expanding demand. Although with the passing of time scientific methods have been more universally used with increasingly satisfactory results, chance still plays a major role in oil discovery. Only by the drill can the precise location of oil pools be determined, their extent delimited, and their probable productivity ascertained.

The unpredictable character of oil discovery has made oil production historically a highly speculative enterprise. The probabilities of losses have been offset by the possibilities of huge gains. An average rate of earnings seems not to have been the appeal to investors in oil production enterprises, nor predictable economic behavior the result. Risks have been great, rewards in some instances likewise great. These circumstances have led to opposing theories: one, that rate of return on investment is not a good regulator of output in the oil industry; the other, that, from a long term viewpoint, investment in additional wells and, therefore, the output capacity of the industry are very directly affected by the rate of return resulting from the price of crude at the time of such investment.

The migratory character of crude oil, the specialized character of the capital equipment, the preponderance of fixed costs in oil production, and the laws of ownership governing the capture of oil have contributed toward a similar functional irresponsibility. Oil in place, intimately associated with gas and water under pressure, is in a condition of delicate equilibrium. Once the underground reservoir has been tapped, this equilibrium is disturbed and the oil seeks its way to the points of diminished pressure, being pushed or pulled to the earth's surface by the escaping gas or driven by encroaching water. The institution of ownership being ill-adapted to the phenomenon of a mi-

gratory mineral, the courts have developed and applied laws of capture to the subjugation of oil. In most of the oil producing states, the oil belongs *de jure* to the individual under whose property it is found. In all of the states it belongs *de facto* to the individual who reduces it to possession. And possession in this case has become ten-tenths of the law.

The speculative character of oil discoveries and the tendency of oil to flow naturally, together with the property laws governing the capture of oil, have shaped the organization and structure of the production branch of the industry. These factors have thus far prevented any great degree of concentration of control through ownership and have given to oil production a continuously and highly competitive character. Thus, although some twenty integrated concerns account for approximately one-half of total crude oil currently produced in the United States, it is estimated that between 15,000 and 18,000 independent producing units produce the other half.

The competitive character of oil production is not fully reflected in the distribution of ownership. Uncertainty with respect to the amount of oil that may ultimately be recovered from a particular pool, and therefore uncertainty with respect to the profits or losses that intensive exploration may promise, together with the necessity of reducing one's property to possession to retain it once a pool has been tapped, make inevitable a system of protective competitive drilling in newly discovered but not fully developed fields with little regard to the economic conditions prevailing in the industry at any particular time. Once the investment has been made in an oil well, its specialized and fixed character together with the fugacity of crude petroleum and the existing rules governing ownership tend to result, in the absence of state interference or of concerted agreement, in operation at capacity with little regard to the price of oil as long as the well is flowing under natural pressure. Almost any contribution to original investment is preferable to the loss of oil through drainage to adjoining leases.

Once wells have ceased to flow and mechanical means are needed to recover additional oil, obviously the promise of return in relation to anticipated costs will afford a basis for judgment as to whether or not the investment should be made. Once the added facilities are installed, however, the owner tends to operate them as long as any return above out-of-pocket expenses is secured. Here again the question is raised whether interest rates, prices, and costs perform in a normal manner the function of regulating current output in the oil industry.

Do such hypotheses lend themselves to statistical analysis? Discovery has been said to be a "function of the quantity of effort and its caliber." How, if at all, may these be measured? What influence does price exert upon them? Is a satisfactory index of search available? What has been the relation between search and discovery? These questions suggest proper objectives of a statistical analysis of cost-price relationships in oil production.

After oil has been brought to the surface it may be stored readily in steel tanks. The exhaustible nature of the resource and the difficulties of controlling output have encouraged the accumulation of large volumes of crude oil in storage. Between 1920 and 1929 total stocks of all oils more than tripled, increasing from 209,000,000 to 689,000,000 barrels.[1] While consumption increased markedly during this period, stocks accumulated more rapidly. Total stocks at the earlier date represented current requirements for 143 days, at the later date for 228 days.

Exhaustibility has been a factor in accounting for a continued search for additional reserves to make good those which have become depleted. Capital has apparently flowed into the industry in anticipation of liberal rewards at some future date when shortage might be imminent. Oil has been stored awaiting a better market. What influence has

[1] See Department of the Interior, U. S. Geological Survey, Petroleum in 1919–1921, and Bureau of Mines Statistical Summary of Refining Products in the United States in 1916 to 1925. Also, Bureau of Mines, Annual Petroleum Statement Number P 69, September 29, 1930.

price exerted upon these developments? What influence have these developments exerted upon price?

During 1926-30, improving technique in oil exploration and oil finding and of random wildcatting culminated in the discovery of reserves at a rate more than double the highest previous annual average. An actual production far in excess of current consumption and the building up of potentials of apparently unmanageable proportions resulted in the development of the current program of output restriction. What effect has this development had upon cost and the price of crude oil? Upon conservation? Controversy centering around these questions suggests the need of unbiased analysis.

TRANSPORTATION AND MARKETING OF CRUDE PETROLEUM

Once oil has been brought to the earth's surface, its liquidity has made possible the development of a unique and singularly efficient system of transportation. Oil from a myriad of scattered wells is collected through a comprehensive network of gathering pipelines. These communicate with an extensive trunk pipeline system through which the oil is driven by pumps located with due regard to the character of the terrain, the viscosity of the oil, and other factors that affect the ease with which the oil may be transmitted through the line. Through such a system crude petroleum is concentrated from widely dispersed pools and delivered to refineries strategically located with respect to markets. Such a system of transportation involves a relatively large capital outlay which, once made, is sharply subject to the principle of decreasing cost in its operation. Operating with capital equipment that is specialized, highly automatic, and fixed, pipeline transportation partakes of the character of a natural monopoly.

This characteristic is reflected in a highly concentrated ownership and control of the existing pipeline facilities. A relatively few large integrated companies control most of the pipeline mileage; some is jointly owned by several companies. Pipelines, although common carriers at law, have

functioned primarily as plant facilities of integrated companies. They have brought to the very mouth of hundreds of thousands of oil wells scattered throughout the United States, owned and operated by thousands of non-integrated oil producers, a market for their product. No adequate analysis has been made of the influence, if any, that pipeline control by the integrated companies exerts upon the price behavior of crude oil or upon cost to refiners. What is the economic significance of 'integrated' and 'joint' ownership of pipelines?

CHARACTER OF PROCESSING

The refining of crude petroleum involves the application of heat and pressure, by means of which the raw material is separated into its components or broken into molecular structures of varying densities and recombined to form the several petroleum derivatives. The mechanical operations utilize the principle of continuous flow and involve the simultaneous production of a variety of petroleum products ranging from heavy residual oils to the volatile naphthas. The process utilizes extensive capital facilities and is automatic in a high degree. In 1937 for each employee engaged in oil refining 12,121 barrels of crude oil were processed and approximately $13,300 of capital utilized. Of the total capacity of 423 refining establishments in operation on January 1, 1937, 22.9 per cent was represented by plants with a daily capacity of 100,000 barrels or more, 15.6 per cent by plants with a daily capacity of from 50,000 to 99,000 barrels, 15.9 per cent by plants with a daily capacity of from 25,000 to 49,000 barrels, 24.6 per cent by plants with a daily capacity of from 10,000 to 24,000 barrels, and 21 per cent by plants with a daily capacity of less than 10,000 barrels. One hundred and four plants, each with a daily capacity ranging from 10,000 to more than 100,000 barrels, accounted for 79 per cent of the total operating capacity of the country, while 319 plants, each with a daily capacity of less than 10,000 barrels, accounted for 21 per cent of the total operating capacity. These figures reflect the extent to

which the refining branch of the industry runs to mass production.

The larger refineries have tended to concentrate near thickly populated centers or water terminals from which ready access by cheap water transportation to such population centers is assured. The smaller refineries have tended to concentrate near oil pools during periods of flush production where access to crude supplies is more certainly assured. Such refinery capacity appears to have been brought into existence during periods of overproduction. Increasing output and declining prices of crude oil and its products seem to have called into being a surplus of refining capacity. What are the facts and what is their significance for price theory? Many of these smaller refineries are of the incomplete or skimming type, are said to depend upon cheap crude for their survival, and to have introduced an unsettling influence into the industry. Frequently these have been the sources of cut-rate gasoline. Statistical analysis directed toward a determination of relative over-all refining costs and the influence the price of crude and the relative degree of product differentiation exert upon such costs promises to be fruitful.

Since oil refining involves the production of joint or by-products, it becomes difficult or impossible to calculate accurately the cost of producing any single product. The large element of fixed cost in oil refining enhances this difficulty. The existence of unused capacity under these circumstances exerts pressure upon prices which makes for instability. If one producer's estimate of the demand and cost conditions for a particular product differs from those of another, price reduction is likely. Temptation to reduce the price of particular products may be increased by a realization that such price reduction will apply to only a portion of the total output of a plant. (A comparable dissimilarity of calculation by other producers of the cost and demand conditions for other jointly produced products may tend to disturb the entire price structure and to introduce ruinous competition throughout the whole range of products.)

What are the practices of the refining branch of the industry with respect to allocation of costs among the several products jointly produced? What influence have these practices upon price? To what extent has surplus capacity acted as a price depressant? What influence has concentration of production in large plants and concentration of large plants under the control of a few companies upon price competition? Is research directed to the answer of these questions feasible?

CHARACTER OF THE MAJOR PRODUCT AND OF THE DISTRIBUTION AGENCIES

Quantitatively and by value the most important of the refined petroleum products is gasoline. The explanation is, of course, found in the automobile. The number of motor vehicles registered in the United States increased from 2.4 million in 1915 to 28.2 million in 1936; domestic gasoline consumption increased from 40 million to 482 million barrels.

Prior to the advent of the automobile, the demand for petroleum rested largely upon the demand for kerosene, in the retail distribution of which general retail establishments played an important role. As the automobile came into general use, a new retail distributive system peculiarly suited to the mobile character of the demand for motor fuel developed. Gasoline moves from the refinery by tanker, pipeline, or railway tank car to terminal or bulk stations. The number of bulk stations in the country is said to be approximately 27,000, of which about 20,000 are operated as units of the major integrated oil companies.[2] From these bulk stations gasoline is delivered by tank wagon to the filling stations and other retail outlets scattered throughout the country. Nearly 180,000 retail establishments, including garages, have installed gasoline pumps as an adjunct to their ordinary retail operation.[3] The bulk of gasoline at retail is distributed, however, by approximately

[2] *U. S. Census of Business, 1935,* Wholesale Distribution.

[3] *American Petroleum Institute Quarterly,* July 1937.

200,000 service stations [4] throughout the length and breadth of the land in every village and hamlet, and on the major highways. They constitute a unique and effective system of retail distribution, but one alleged by some to be costly. They have made available to the motorist his choice of a multiplicity of branded and unbranded gasoline in the sale of which advertising plays an important role.

Only a minority of these service stations, estimated at approximately 15 per cent, are owned or operated directly by the agencies that supply them with gasoline. This does not preclude, however, the possibility that the supplying companies may have influenced considerably the business policies, including price determination, of the stations operated by independent dealers. Through leasing and licensing agreements and other contractual arrangements, the supplying company may have influenced pricing procedures. Moreover, a considerable number of dealers sell unbranded or jobber-branded gasolines secured through independent jobbers, and other dealers handle several brands.

During the last decade or more, the number of retail outlets has increased more rapidly than the total volume of gasoline distributed annually, with a consequent lowering of the average quantity sold annually per outlet. The nominal gross margins of retailers, suggestive of higher merchandising costs, have increased, but the intensifying of competition, characterized at times by price wars, has kept actual margins at a level substantially below nominal margins. The vigorous development of retail outlets for gasoline reflects in part the influence that has led to duplication in retail facilities generally, viz., the lack of heavy demand upon capital, skill, or experience as a prerequisite to entering the business in a modest way. It was also a means of employment for thousands during the depth of the depression who found a livelihood in the tolerably well sustained demand for gasoline. On the other hand, it reflects a competitive drive for retail gasoline service station business

[4] *U. S. Census of Business, 1935,* Retail Distribution.

among the major integrated oil companies in the face of a rapidly expanding supply of crude petroleum. It has been in part the result of a program designed to assure an appropriate balance among the facilities employed at the several stages in the integrated operations of the major oil companies, each endeavoring thereby to fortify its competitive position in the market. Likewise, it has reflected a desire of the integrated companies doing business over a broad geographic area to reap the full advantage of a national program of radio and periodical advertising. A broader and perhaps more basic influence has been the surplus of crude oil that has been discovered and produced. As this surplus has endeavored to push its way on to the market it has tended to create an excess of facilities from the well to the filling station.

The above brief analysis of the marketing machinery suggests points of attack in a research program on oil prices. Has price afforded an adequate check to overexpansion? Have facilities adjusted themselves to the economic requirements of the situation? How do handling costs vary with variations in gallonage? What has been the course of nominal and actual margins in gasoline distribution at wholesale and retail? What influence have these margins exerted upon price stability? To what extent has marginal handling cost influenced dealer margins?

At prices that have customarily prevailed there is no adequate substitute for gasoline as a fuel for internal combustion engines. Moreover the automobile, dependent upon gasoline for its motor power, has wrought such marked changes in American living habits and in business methods that it is no longer to be classed as a luxury. It is now considered an indispensable asset in the everyday life of the common man. Under these circumstances the consumption of gasoline has shown no such cyclical fluctuations as have goods of the luxury class or durable capital goods. It would seem that the amount of gasoline consumed would be but slightly affected by its price so long as that price remains within the range of customary price fluctuations. As gaso-

line has become a universal source of state revenue derived from taxes placed directly upon it, the question of the influence of price upon consumption has become of greater concern to the several states. For the industry, confronted with a surplus of output and facilities, and for the consumer, interested in economizing his purchasing power, this problem has attained very considerable importance. It requires a more thorough exploration than it has yet been subjected to. Because of the joint character of the production of the whole range of petroleum products, the influence of price upon consumption would seem to be a particularly important field of inquiry.

Excess capacity has been particularly marked in the two end phases of the industry—production and distribution. These have likewise been the points at which competition has been keenest and in which ownership has been most widely disseminated. They have accordingly been the points toward which the stabilization efforts of the industry have been primarily directed. This stabilization program has been largely under the leadership of the major concerns whose integrated activities cover the whole range of productive operations from discovery and production of crude petroleum through transportation, refining, to marketing. For it should be observed that integration and large scale enterprise have been two of the more important characteristics of the business organization under which the oil industry has carried on. These characteristics are reflected in the fact that a group of 22 companies, with a total net domestic investment approximating 5 billion dollars and representing nearly two-thirds of the industry's total domestic investment, account for approximately one-half of the country's production of crude, three-fourths of its refining capacity and about 95 per cent of its pipeline mileage.

The stabilization efforts of the industry in the production branch have taken the form of a program of curtailment and proration, already referred to. In the marketing branch stabilization efforts have been directed primarily toward the standardization of certain practices—price-posting, lend-

ing equipment, granting of premiums, etc. What has been the effect of the curtailment program upon the cost and price of crude oil and upon conservation? What influence have the pricing methods adopted in marketing exerted upon price levels and price stability?

More recently, apparently in an effort to reduce or shift the costs of retail station operation, and to get larger gallonages through the greater price flexibility and sales efforts of individual entrepreneurs, the so-called Iowa Plan has been generally inaugurated in retail marketing. Under this plan the supplying company leases its stations to individual dealers or operators. One result of this change in arrangements seems to be a greater degree of dealer independence in price determination. Under the 'Iowa Plan', gasoline is no longer sold to dealers at a discount from the supplying company's posted retail price, but at a wholesale price to which the independent dealer adds such margin as in his discretion seems expedient. What influence upon price stability, retail prices, margins, station gallonage, etc., will the 'Iowa Plan' have? What effect will it have upon jobbers? Upon the organization of the wholesale and retail structure?

This brief discussion of the structure and organization of the oil industry and the characteristics of its several processes and major products indicates the sort of questions toward the solution of which a price research program might properly be directed. Before setting forth in more specific terms the objectives of such a program, the available statistical materials will be surveyed and their significance and deficiencies appraised.