Structure of the Soybean Processing Industry

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CONTENTS

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STRUCTURE OF THE SOYBEAN PROCESSING INDUSTRY

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The soybean processing industry in the United States has expanded rapidly in the past few decades. In this process of rapid development the industry seems to have provided a place for processing plants of different sizes and types. But since the expansion has slowed down in recent years, processors have found it necessary to reexamine the economic factors that affect their operations and competitive position in the industry.

The main purpose of this study is to describe and analyze the development and existing structure of the soybean processing industry in the United States, with the hope that such information will provide a basis for understanding the past, present, and future developments of the industry. As such, this report will be useful to processors, handlers, and growers of soybeans both in the United States and other countries.

Growth and Development of the Soybean Industry

Pioneering Period

Although some seeds of the soybean were brought into the American continent from the Orient as early as 1804, little attention was paid to them except as a curiosity until about the turn of the century.[2] In 1898, the United States Department of Agriculture began introducing a great number of soybean varieties from Oriental countries. But there was little interest in growing soybeans for the oil or protein of the seed. In the early years of the present century, the research at agricultural experiment stations and universities was concerned chiefly with the use of the soybean plant for hay, for animal feeding, or for soil improvement, with no thought of industrial utilization.

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[2] A good description of the pioneering period of soybean production and processing in the United States is found in E. J. Dies, *Soybeans: Gold from the Soil,* 1942.

European countries, especially England, started importing soybeans in quantity from Manchuria in 1908, with the intention of manufacturing soybean oil and meal to remedy a shortage of cottonseed and linseed. Considerable quantities were imported by England where many of the oil plants devoted their operations entirely to the crushing of soybeans. These mills conducted series of tests and experiments to demonstrate the value of cake, meal, and oil. The utilization of soybeans as an oilseed spread rapidly to other European countries, and soon after the first cargo shipment of 9,000 tons of soybeans to England by a Japanese firm in 1908, the European importations of soybeans from Manchuria and Japan increased rapidly. Oil was used mostly in soap manufacturing; soybean cake or meal was consumed as feed especially for dairy cows in Denmark, Sweden, Norway, Holland, and the northern part of Germany.

Following the earlier success in the utilization of soybeans as oilseed in European countries, soap and paint manufacturers in the United States began experimenting with soybean oil in their manufacturing process, which soon led to large importations of soybean oil from Asia and Europe. Gradually a few individuals became interested in processing the soybean for its oil and meal, and in 1911 Herman Meyer, who had a small crushing plant in Seattle, started crushing imported Manchurian soybeans for oil and meal. He sold oil for industrial use and meal as high protein feed, but his venture was not successful.

During World War I there developed a shortage of cottonseed in the South and a surplus of soybean seed in the seed-producing areas. This led to an increased interest in the soybean as a source of oil and meal. In those years most of the soybeans were grown in North Carolina and were first processed in 1915 by the Elizabeth City Oil and Fertilizer Company at Elizabeth City, North Carolina. Several cottonseed oil plants also started production of soybean oil and meal but only a small quantity of domestic soybeans was crushed, due mainly to the high price of the seed which was in strong demand for planting as hay.

The use of soybean oil in the soap and paint industries in the United States was expanding, and a general shortage of fats and oils during World War I made it necessary to import increasing quantities of Manchurian soybean oil. In 1918, the United States imported 344 million pounds of soybean oil. In addition, soybeans were also imported from Manchuria during the war years and utilized by the cottonseed oil plants in the South.

By the end of the war soybean planting became popular and acreage planted to soybeans was expanding rapidly, most markedly in Illinois.

But in those early years most farmers grew soybeans for hay, and if harvested for beans most of the crop went for seed, leaving only a small quantity to be processed into oil and meal.

In Illinois, the A. E. Staley Company announced in 1921 that its soybean plant would be ready for the 1922 crop, saying that the project was in response to the general and urgent desire on the part of the farmers of central Illinois for such a plant.[1] However, when the operation of the Staley plant started in September 1922, the first problem was to secure an adequate supply of soybeans for the crushing operation. At that time soybeans could be purchased only in small lots and "even sometimes by the wagonload"; moreover, the quality of the soybeans was uneven due to farmers' inexperience in cultivating and harvesting the crop.

It is interesting to note that from the very beginning the capacity of the soybean processing industry exceeded the production of soybeans. This was true until very recently. The excess capacity induced the processors to compete intensively for the available soybean crop and produced excellent markets for soybean growers. The competition also encouraged the development of more efficient firms with a lower unit cost of processing.

In the embryonic stage of the soybean processing industry several other companies started crushing soybeans — the Funk Brothers Seed Company in 1924, the William O. Goodrich Company in 1926 (acquired by Archer-Daniels-Midland Company in 1928), the American Milling Company in 1927, the Shellabarger Grain Products Company and the Archer-Daniels-Midland Company in 1929, the Central Soya Company in 1934, and the Spencer Kellogg Company in 1935.

As more plants started processing soybeans it became increasingly difficult for them to secure sufficient quantities of soybeans for their operations. In order to cope with this situation, the so-called Peoria Plan was developed by three processors in 1928. They offered a guaranteed minimum price to growers in Illinois for soybeans delivered at their plants.[2] The following year a guaranteed price was offered to growers in Indiana and Ohio as well.

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[1] *Pioneering a New Industry — A History of the A. E. Staley Manufacturing Company's Activities in the Soybean Industry.* Published by the A. E. Staley Manufacturing Co.

[2] The three processors were: The G.F.L. Exchange of New York, The Funk Brothers Seed Company, and The American Milling Company. The guaranteed price offered in 1928 was $1.35 a bushel. (*The Soybean Digest,* September 1944, pp. 18-23.)

Tariff Problem

In the course of expanding soybean production and processing, the farmers and processors were facing a competition from imported soybeans and soybean products. Until 1930, soybean producers had some protection on soybeans and oil but none on the meal. With the increased demand for soybean products in the United States, both growers and processors wanted greater tariff protection for their expanding programs. The American Soybean Association sent a small group of members to Washington in the winter of 1928-29 in the interest of tariff protection on soybeans and soybean products. In June 1930, the Smoot-Hawley Tariff was passed, stipulating a tariff of 2 cents per pound or $1.20 per bushel on soybeans, 3½ cents per pound on soybean oil (but not less than 45 percent ad valorem), and 0.3 cent per pound or $6.00 per short ton on soybean meal. With this high tariff protection soybean production and processing in the United States continued to increase very rapidly during the 1930s.

Rapid Growth

The second stage of development of the soybean processing industry in the United States began in 1935, after about two decades of pioneering work in the industry. That year, for the first time, the quantity of soybeans processed for oil and meal reached more than half of the total supply of soybeans, and during the next ten years the soybean processing industry firmly established its position in the fats and oils industry of the United States.

In 1934 there were 19 soybean processing plants which crushed a total quantity of 9 million bushels of soybeans. In 1935 the number of plants increased to 49, and the total crush was 25 million bushels. During the subsequent few years prior to the outbreak of World War II the soybean production and processing continued to increase fairly rapidly. The proportion processed of the total production of soybeans increased from 51 percent in 1935-36, to 82 percent in 1940-41, in which year the quantity processed reached 64 million bushels.

In 1941-42 the soybean industry started an expansion program to meet the increased war demands for fats and oils and high protein feeds. Because fats and oils from abroad were in short supply the domestic production had to be stepped up to make up for reduction in imports and also to meet the sudden increase in demand. Soybean production in the 1939-40 season was 90 million bushels, but during the war years it continued to increase very rapidly until it reached a level of 192 million bushels in the 1944-45 crop year. In the same period the crush increased from 57 million to 153 million bushels.

On April 1, 1942, there were a total of 79 soybean plants, excluding those plants located on the west coast and in the southern states which processed only small quantities of soybeans. They had an estimated annual capacity of 106 million bushels. By comparison, on July 1, 1944, there were 137 soybean plants, including those in operation, under construction, and those for which priorities had been approved prior to July 1, 1944. These had an annual capacity of about 173 million bushels.[1] There was a further increase of 23 plants in 1945, for a total of 160 with a capacity of 189 million bushels.

Postwar Period

Following the end of World War II, the soybean processing industry in the United States continued to expand steadily to meet the increasing demand for fats and oils and high protein feeds. In 1948 there were 185 plants with a capacity of about 200 million bushels. During the five-year period immediately after the war the crush did not increase very much. In 1950-51 both soybean production and processing took increases of 60 million bushels, after which they both leveled off for three years. Again in 1954-55, soybean production and processing started an upward trend, and in 1961-62 they amounted to 680 and 439 million bushels, respectively.

In the 1950s the soybean crush increased by more than 50 percent, from 252 million in 1950-51, to 393 million in 1959-60. But the number of processing plants decreased considerably in the same period. In 1957-58 there were 139 soybean plants, or 54 less than in 1950-51. Yet the capacity of these fewer plants was much greater, indicating an increase in the average size of plant.

Expanding Markets for Soybean Products

The rapid development of the soybean processing industry in the past few decades has been possible because of the equally rapidly expanding markets for processed soybean products — soybean oil and soybean meal. These two are joint products in the sense that they are produced together in nearly constant physical proportions. Oil yield

[1] Schiffman, E. G. Soybean mills, their capacity and ownership. *The Soybean Digest*, October 1944, p. 11.

per bushel of soybeans has somewhat increased due to the improvement of extraction method and to the introduction of varieties with higher oil content, but essentially the physical proportions between oil and meal are constant. This is in contrast to the other major oilseeds. Soybeans produce nearly twice as much meal per pound of oil as cottonseed and safflower and about three times as much as peanuts, a situation which affects the competitive position of soybeans and the soybean processing industry in the fats and oils market.

Utilization of soybean oil. Soybean oil belongs to the semi-drying class of oils. Crude soybean oil is yellow to dark brown in color and has a faint odor, somewhat "beany" but rather palatable. For food purposes, soybean oil is refined through deacidifying, bleaching and deodorizing processes, the product being a neutral bland oil closely resembling refined cottonseed oil, light yellow in color, and nearly odorless and tasteless.

Nonfood uses. About 1908, due to the scarcity of cottonseed and linseed supplies, soap and paint manufacturers in the United States began to turn their attention to the possibilities of using soybean oil in their products. In the 1920s these two uses were the major outlets for soybean oil. By 1933, the combined nonfood uses, including soap, paint and other drying oil products, amounted to 73 percent of the total domestic disappearance of soybean oil. But as food uses increased after 1935, the percentage of nonfood uses in the total domestic consumption decreased to an average level of 18 percent for the period from 1935 to 1944, and further to the average of 14 percent for the next ten years from 1950 to 1959. In 1960, nonfood uses accounted for only 10 percent of the total domestic consumption.

In terms of absolute quantities, uses of soybean oil for paint and varnish and other drying oil products increased gradually until the early part of the 1950s. But as synthetic resin products came on the market, consumption of soybean oil for these uses leveled off and began to decline. Use of soybean oil in soap manufacture decreased greatly during World War II due to the strong demand for edible fats and oils. This resulted in the substitution of tallow and the production of synthetic detergents. Today consumption of soybean oil for soap manufacturing is almost nil except for the use of foots or soapstock.

Food uses. Soybean oil production has increased rapidly in the past few decades. Production averaged 42 million pounds for the five-year period 1930-34, and increased by 1940-44 to an average output of 1,009 million pounds. This level was more than tripled by 1955. Production continued to increase, and by 1960 it reached a level of 4,420 million pounds.

Soybean oil utilization has increased so rapidly largely because of its acceptance as an edible oil. In the 1920s and the early 1930s soybean oil was at a disadvantage in the edible oil market because of certain qualities of instability, and because of the "beany" smell. In addition, the prices of soybean oil were slightly higher than those of cottonseed oil in the early period. But since 1934 soybean oil prices have been lower than those of cottonseed oil prices.

During the pioneering years, research was being conducted to develop a method of refining the soybean oil for edible use. In 1926, semi-refined oil was first produced on a plant scale, and by 1935 research proved that soybean oil could be hydrogenated and used in margarine with good results. Hydrogenation tended to reduce the advantages that some oils formerly held over soybean oil, because deodorization is practically complete in hydrogenation. Hydrogenation of soybean oil meant that soybean oil could become competitive with cottonseed, peanut, and other oils used in shortening and margarine.

Since 1935, soybean oil has been used largely in food products, chiefly for shortening and margarine. Uses also increased greatly for other food products, such as mayonnaise and salad oils. Particularly after the outbreak of World War II, imports of fats and oils into the United States were greatly curtailed and the domestic production of soybeans was stepped up. Increasing quantities of soybean oil were used for food products. In the ten-year period from 1935 to 1944, margarine use accounted for 19 percent of the total quantity of soybean oil used for food products, shortening 56 percent, and others 25 percent. Others include mayonnaise, salad dressings, direct use in homes, bakeries, restaurants, and other miscellaneous food uses. After the war margarine use increased most in relation to other uses, next followed by uses for miscellaneous food products. From 1950 to 1959, 34 percent of the soybean oil for food products was used for margarine, 41 percent for shortening, and 25 percent for other food products. In recent years margarine use has been equal to or greater than the consumption of soybean oil in shortening manufacture. Today food products account for about 90 percent of the total domestic consumption of soybean oil.

Soybean oil has been of increasing importance in the edible fats and oils market in the United States. Of the total edible oil consumption of 5.6 billion pounds in 1935, only 0.1 billion or 1.8 percent was soybean oil, whereas in 1960 soybean oil comprised 3.1 billion pounds or 37.6 percent of the total quantity of 8.2 billion pounds of edible fats and oils used. An important consideration is that this increase in consumption of soybean oil has been associated with increased population, relative stability in per capita consumption of total fats and oils, and an inelastic supply of competing fats and oils. Because of the improved technology in refining and manufacturing, all edible fats and oils are in large measure interchangeable, and therefore, competition largely depends upon relative prices of individual fats and oils.

The nonprice factors which have affected the utilization of various edible fats and oils are many, but three may be considered important. They are (1) the government farm programs which have affected production of oilseeds, (2) technological developments which have affected the processing and refining of oils and manufacturing of oil-based products, and (3) demand patterns for oils and oilseed meals.

Larger supplies of soybeans and the limited production of cottonseed due to government programs during recent years have naturally encouraged production and utilization of soybean oil rather than other fats and oils. Improved technology has made it possible to substitute soybean oil for most other edible fats and oils in food products. The characteristic difference in the nature of demand for oils and oil meals, that is, a negative income elasticity of demand for edible oils as contrasted with a positive elasticity for oil meals as high protein feeds, has strengthened the competitive position of soybeans because of the lower oil content and higher protein content. Processors are concerned with the total combined selling value of the joint products of oil and meal rather than with the individual price of either oil or meal. Therefore, with a favorable market for large quantities of soybean meal, processors are willing to sell large quantities of oil in the edible oil market at a relatively low price, which naturally promotes further substitution of soybean oil for other edible fats and oils.

Exports. Up to 1937, the United States had usually been a net importer of soybean oil, although as domestic production increased during the 1930s the imports fell off from the peak period of 1916 to 1920 which saw average annual imports reach 200 million pounds.

In the postwar years, because of the tremendous increase in production and processing of soybeans during World War II, the United States became a net exporter of soybean oil. From 1948 through 1951, soybean oil exports from the United States (mostly to Europe) reached a considerable volume, averaging 338 million pounds a year, or about 16 percent of the annual soybean oil production. In 1952 through 1954, exports declined sharply, but after 1954 when soybean oil was designated as a surplus commodity available for export for foreign currencies under the P.L. 480 programs, exports of soybean oil increased again. In 1959, the combined exports through private commercial channels and the government programs reached a level of 950 million pounds, or 22 percent of the total soybean oil production of the year. Since 1955, the export shipments have accounted for about 20 percent of the total production. Foreign markets have thus become an important outlet for soybean oil produced in the United States.

Utilization of soybean meal. During the 1920s when only very small quantities of soybeans were processed in the United States, imports of soybean meal were greater than the domestic production, although the total volume of imports was quite small, ranging from 20,000 to 74,000 tons per year. All the meal was used for feed.

Since 1930, as the quantities of soybeans processed for oil and meal increased, the domestic production of meal increased in proportion to the increase of processing, yet small quantities of imports continued until the outbreak of World War II. In line with the rapid development of the processing industry, the volume of production of soybean meal continued to increase year after year until it reached a level of 10.3 million tons in 1961.

During all these years of rapid and continuous increase in production, soybean meal has been used almost exclusively for feed. From 1935 to 1944, the use of soybean meal for feed accounted for 97 percent of the total domestic production, and 95 percent in the ten years from 1950 to 1959. The largest portion of soybean meal has been used in poultry feed, although the biggest increase of meal consumption in the recent past has been in feeds for hogs.

In the postwar years the United States has become an exporter of soybean meal, but the quantities exported were not large, averaging only about 4 percent of the total production in the period of 1950 to 1959. In the past few years, however, exports of soybean meal have been increasing rapidly, reaching a level of about 15 percent of production in 1962-63. Different from the case of soybean oil, the domestic demand for soybean meal in the United States has so far been strong enough to absorb almost all the meal produced from the increasing quantities of soybean crush. This situation is likely to continue in the future in view of the growing demand for mixed feeds by the livestock and poultry industry.

The main factors that have contributed to the rapid expansion of soybean meal consumption in the United States are increasing livestock population, increasing intake of high protein concentrates per animal unit, and the rapid expansion of the mixed feed industry. All these factors depend upon strong demand for livestock products, especially meat.

In meeting requirements for high protein concentrates in feed, soybean meal competes with other oilseed meals, mainly cottonseed and linseed meal in the United States. But in the case of soybeans, meal may be considered the main joint product, whereas linseed and cottonseed meals are by-products of linseed oil and cotton fibre, the demand for which largely determines the supply of linseed and cottonseed meals. Because of this basic difference as compared with other oilseed meals, soybean meal is in the best position to meet directly the real and potential demand for high-protein concentrates. In the past few decades the consumption of soybean meal has continued to increase at a rapid rate, while that of linseed and cottonseed meals has not increased. This trend is likely to continue.

Technological Development

The major technological development in the soybean processing industry in the United States has been the change of the method of processing from the mechanical process to a chemical or solvent process of extraction.

The hydraulic-press method, which consists of an intermittent pressing operation carried out at elevated temperatures in a hydraulic press after the soybeans have been rolled into flakes and conditioned by heat treatment, was the first used in processing soybeans during the pioneering period. This method was rapidly replaced after 1930 by the more efficient screw-press method of oil extraction. The screw-press method is a continuous pressing process, at elevated temperatures, using expellers or screw presses which utilize a worm shaft continuously rotating within a pressing cylinder or cage to express the oil from soybeans after they have been ground and conditioned.

As shown in Table 1 the screw-press method remained the leading process in the industry until the 1948-49 season, after which the solvent method of extraction increased rapidly and gained the leading position. Solvent extraction is a chemical process whereby the oil is leached or washed from flaked soybeans by the use of hexane, a homologous hydrocarbon solvent. In the 1952-53 season the solvent method accounted for about 86 percent of the soybeans processed, and the proportion rose to 95 percent in 1956-57, the remaining 5 percent being processed by

Table 1. — Quantity of Soybeans Processed by Method of Extraction, Annual 1936-49, 1951 1952, 1956, and 1957, Year Beginning October

Crop year	Hydraulic press		Screw press		Solvent extraction		Total	
	(thousands of bushels)	(percent)	(thousands of bushels)	(percent)	(thousands of bushels)	(percent)	(thousands of bushels)	(percent)
1936	3,804	18.4	14,092	68.4	2,720	13.2	20,616	100.0
1937	3,872	12.8	21,249	70.1	5,186	17.1	30,307	100.0
1938	5,269	11.8	32,236	72.2	7,138	16.0	44,643	100.0
1939	3,069	5.4	42,463	74.4	11,534	20.2	57,066	100.0
1940	1,749	2.7	47,512	74.2	14,788	23.1	64,049	100.0
1941	1,375	1.8	57,151	74.1	18,598	24.1	77,124	100.0
1942	27,290	20.5	84,359	63.2	21,791	16.3	133,440	100.0
1943	26,136	18.4	92,853	65.2	23,303	16.4	142,292	100.0
1944	14,576	9.5	108,182	70.5	30,629	20.0	153,387	100.0
1945	12,111	7.6	102,442	64.2	44,907	28.2	159,460	100.0
1946	16,271	9.5	108,744	63.9	45,224	26.6	170,239	100.0
1947	12,933	8.0	88,233	54.4	61,000	37.6	162,166	100.0
1948	9,351	5.1	101,535	55.3	72,773	39.6	183,659	100.0
1949	5,729	2.9	80,546	41.2	109,258	55.9	195,533	100.0
1951	3,480	1.4	60,440	24.9	178,922	73.7	242,842	100.0
1952[a]	([b])		32,817	14.0	201,587	86.0	234,404	100.0
1956[a]	([b])		15,797	5.0	300,153	95.0	315,950	100.0
1957[a]	([b])		24,059	6.8	329,746	93.2	353,806	100.0

[a] Estimates based on *Capacity and Processing Trends in the Fats and Oils Industry,* Marketing Research Report 360, September 1959, AMS, USDA, p. 9.
[b] Included with screw press.
Source for 1936-51: *Processing the Three Major Oilseeds,* Marketing Research Report No. 58, April 1954, AMS, USDA, p. 6.

the screw-press and hydraulic methods, chiefly by plants located in the cotton states which process soybeans after the supply of cottonseed has been exhausted.

The immediate impact of solvent extraction on the industry was the enlargement of processing capacity of individual plants, because solvent processing, especially the recent system of continuous extraction, lends itself to large crushing operations. And in recent years another technological advantage has evolved out of the solvent method. It is the development of a continuous expeller-solvent extraction system which can efficiently crush different oilseeds. This development has been particularly beneficial to southern areas where a multi-seed extraction system enables a cottonseed crusher to operate on soybeans after the cottonseed crushing is over. Thus the new method contributes to higher flexibility and efficiency of processing plants.

Expanding Soybean Production

Total acreage. The total United States acreage of soybeans planted for all purposes increased most rapidly during the 1930s. A further expansion of acreage ensued following the outbreak of World War II, but the rate of increase was lower than that of the 1930s. In the immediate postwar years the acreage decreased slightly, but later as exports started increasing rapidly, soybean acreage resumed its increase, and in 1960 planted acreage was twice that of 1940, reaching the level of 24.6 million acres. In terms of acreage harvested for beans, the increase from 1940 to 1960 was five-fold, from 4.8 million to 25.6 million acres.

Geographical distribution of soybean acreage. From the earliest period of soybean cultivation in the United States the corn-belt states have been the main producing area because of the favorable climatic and soil conditions and also because of the adaptability of corn farming practices to soybean cultivation. During World War II, the concentration of soybean acreage in the corn belt was highest and accounted for a little more than two-thirds of the total acreage of soybeans in the nation. But gradually, as improved varieties became available, and as farmers in other areas became better acquainted with cultivation of soybeans, the acreage expanded into the north and the south. After restrictions were placed on cotton, wheat, and corn acreages in 1954, soybean plantings increased relatively more in the delta area and the southeast than in the corn belt.

Development of soybean varieties. Through efforts of research workers, important improvements have been made in climatic adaptability, yield of seed, oil content, and resistance to lodging, shattering, and disease. Although soybeans are adaptable to a wide range of climatic and soil conditions, without the effort of plant breeders to develop varieties better suited to local conditions in the United States, soybean cultivation would be confined to more limited areas than it is today.

Yields and production. Increase in soybean production has been due mainly to increase in soybean acreage. But increased yield per acre has also contributed to increase of soybean production. From 1924 to 1929, the average yield of soybeans per acre was only 12.2 bushels, but it increased gradually, and in 1961 it reached a record level of 25.2 bushels. The three main reasons for this increase in yield were (1) improvement of varieties for better adaptability to local conditions, (2) technological improvement in harvesting soybeans, and (3) improved planting and cultural practices including better weed control.

Harvesting soybeans has been one of the most difficult problems in the development of soybean production in the United States. Most varieties tend to shatter when they reach the stage of maturity and special attention is required to prevent losses in harvesting. The proper use of the combine resulted in a marked reduction of soybean losses at harvest, and enabled farmers to grow more soybeans with higher yields.[1]

Government farm programs affecting soybean production. Various government farm programs for both soybeans and other crops have been an important factor in the development of soybean production in the United States. As early as the 1930s, the programs of the Agricultural Adjustment Administration contributed directly and indirectly to the expansion of soybean acreage; directly through payments to the farmers who kept a part of their crop land in soybeans for hay or plowing under as a soil-conserving practice, and indirectly through the restrictions on corn acreage. During the war years the price support programs for soybeans were introduced to encourage production. In the postwar period acreage restrictions for cotton, corn, and wheat, which had been introduced during the 1930s but discontinued during the war, were again restored. This resulted in a decrease in acreage of restricted crops and an increase in soybean acreage because much of the released land was diverted to soybeans (Table 2).

In 1956, the soil bank scheme was adopted in addition to the acreage allotments in an attempt to reduce further the production of the basic crops, which are by legal definition corn, wheat, cotton, rice, tobacco,

[1] Ross, R. C. *Soybean Costs and Production Practices.* Ill. Agr. Exp. Sta. Bul. 428, 1936.

Table 2. — Changes in Harvested Acreages of Soybeans and Other Selected Crops, Corn Belt, South, and U.S., Selected Years, 1949-60

Area	1949	Change in acreage from 1949 through				Percentage change 1949-60
		1950[a]	1953[b]	1957[c]	1960[d]	
	(millions of acres)	(millions of acres)				(percent)
Corn belt[e]						
Corn	33.2	−3.4	−.4	−3.6	+2.8	+8
Hay	13.0	+1.7	+.8	−.1	−1.0	−8
Oats	14.1	0	−1.9	−3.1	−5.9	−42
Soybeans	7.8	+2.0	+2.4	+5.2	+6.0	+77
Wheat	8.1	−1.4	−.2	−1.8	−2.2	−27
Total	76.2	−1.1	+.7	−3.4	−.3	0
South[f]						
Corn	16.9	+1.2	−3.0	−4.8	−5.6	−33
Cotton	23.3	−8.2	−3.5	−12.0	−10.8	−46
Hay	10.4	−.6	−.4	−1.3	−1.7	−16
Oats	3.3	+.1	+.7	+1.6	−.4	−12
Soybeans	1.0	+.6	+.8	+2.3	+4.2	+420
Wheat	14.0	−6.1	−4.2	−7.0	−4.2	−33
Total	68.9	−13.0	−9.6	−21.2	−18.9	−27
United States						
Corn	85.6	−3.8	−5.1	−13.0	−3.5	−4
Cotton	27.4	−9.6	−3.1	−13.9	−12.1	−44
Hay, all	72.8	+2.3	+2.2	+.6	−3.5	−5
Oats	37.8	+1.5	−.3	−3.1	−10.7	−28
Soybeans	10.5	+3.3	+4.3	+10.3	+13.0	+124
Wheat	75.9	−14.3	−8.1	−32.1	−23.3	−31
Total	310.0	−20.6	−10.1	−51.2	−40.1	−13

[a] Acreage restrictions on corn, cotton, and wheat.
[b] No acreage controls.
[c] Acreage restrictions on corn, cotton, and wheat. Soil Bank Program in effect.
[d] Acreage controls on cotton and wheat but not corn. Soil Bank Program in effect.
[e] Illinois, Iowa, Indiana, Ohio, and Missouri.
[f] Southeastern states plus Mississippi, Tennessee, Louisiana, Arkansas, Texas, and Oklahoma.
Source: *Fats and Oils Situation*, ERS, USDA, May 1961, p. 29.

and peanuts. The Public Law 480 programs, under which soybean and cottonseed oils have been exported since 1954, have also had an indirect but effective influence on expansion of soybean acreage through the disposal of surplus oil. In 1961, there was an increase in support level from $1.85 to $2.30 per bushel, and the feed-grain program was introduced in an effort to reduce production of feed grain. These government programs, coupled with high prices of soybeans in the spring of 1961, induced a big increase in soybean acreage and production.

Location of Soybean Processing Plants

From the beginning of the soybean processing industry, plants have been largely concentrated in the main areas of soybean production.

The leading production area has been Illinois and it has also been the leading processing area.

Of the 47 soybean processing plants that were operating in the United States in 1939, 14 plants were in Illinois, 6 in Iowa, 7 in Ohio, and 20 in other states.[1] In 1942, there were 79 plants processing soybeans. These had a total capacity of 106 million bushels, 71 percent of which was in the four largest soybean producing states of Illinois, Iowa, Indiana, and Ohio. The number had increased to 137 in 1944, in which year 81 percent of the 172 million bushel capacity was in the four states mentioned. In 1950, there were 251 plants processing soybeans either exclusively or as part of their operations. Of this total number, 139 plants processed soybeans exclusively, and these plants were highly concentrated in the traditional four soybean producing states.

Since the early 1950s, the total number of soybean plants has decreased greatly. It is interesting to note in this connection that the rate of decrease is fairly even in all soybean processing regions except Minnesota and the southern states (Table 3).[2]

1951-52 industry survey. According to the special survey made by the Bureau of the Census at the request of the United States Department of Agriculture during the 1951-52 marketing season, there were 193 plants which processed soybeans in the United States, and 128 of these processed soybeans exclusively, the rest being primarily cottonseed oil plants which crushed soybeans after their supply of cottonseed had been exhausted.[3] Of the 193 plants, nearly one-half (85), were in the four states of Illinois (31), Iowa (30), Ohio (14), and Indiana (10), and 80 of these plants processed only soybeans.

In the four major soybean states, 39 plants employed the solvent process, which represented more than half of the solvent extraction plants processing soybeans in the United States during the 1951-52 season.

Illinois had the largest number of solvent extraction plants — 15. It also processed the largest quantity of soybeans — 78.4 million bushels, the average amount of processing per plant being 5.2 million bushels. In terms of total quantity processed, Iowa was the second with 28.1 million bushels, but the average for processing per plant of 2.2

[1] *U.S. Census of Manufacturers,* 1939.

[2] The figures are based on the directory of processors provided in the *Soybean Blue Book* of the American Soybean Association, and do not necessarily coincide exactly with the USDA survey figures for particular years.

[3] *Processing the Three Major Oilseeds,* April 1954, Marketing Research Report No. 58, AMS, USDA.

Table 3. — Geographical Distribution of Soybean Processing Plants, 1950-61

State	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Illinois	32	31	31	31	31	29	26	25	22	20	20	17
Iowa	33	30	29	26	25	24	24	23	23	23	22	22
Ohio	15	14	14	11	9	9	9	9	8	8	8	7
Indiana	10	9	10	10	10	8	8	6	5	5	5	5
Missouri	10	10	10	10	8	7	7	5	4	4	4	4
Total	100	94	94	88	83	77	74	68	62	60	59	55
Minnesota	9	9	9	9	8	8	9	8	7	8	8	9
Michigan	1	0	0	0	0	0	0	0	0	0	0	0
Wisconsin	2	2	2	1	1	1	0	0	0	0	0	0
Total	12	11	11	10	9	9	9	8	7	8	8	9
Kansas	6	6	5	4	3	3	3	3	3	3	3	4
Nebraska	3	3	3	3	3	3	2	2	2	2	3	3
South Dakota	1	1	1	0	0	0	0	0	0	0	0	0
North Dakota	1	1	1	1	1	1	1	1	1	1	1	1
Oklahoma	8	8	8	8	7	7	7	6	3	3	3	3
Total	19	19	18	16	14	14	13	12	9	9	10	11
Arkansas	12	12	12	13	13	12	12	11	9	11	11	11
Mississippi	19	19	18	18	20	20	18	19	14	15	15	13
Louisiana	4	4	3	3	3	3	3	3	2	2	1	1
Total	35	35	33	34	36	35	33	33	25	28	27	25
North Carolina	14	15	15	15	15	15	14	11	8	8	7	7
Virginia	3	3	3	3	3	1	1	0	0	1	1	1
Delaware	1	1	1	1	1	1	1	1	1	1	1	1
South Carolina	8	6	7	7	7	7	5	5	4	6	7	7
Georgia	11	11	8	8	8	7	6	5	3	3	3	3
Alabama	9	9	9	9	9	9	5	4	3	3	4	4
Florida	1	1	1	1	1	2	2	2	2	2	2	2
Total	47	46	44	44	44	42	34	28	21	24	25	25
Other	37	36	36	35	28	26	25	23	20	18	19	20
Total	250	241	236	227	214	203	188	172	144	147	148	145

Source: Directory of soybean processors provided in *The Soybean Blue Book* of the American Soybean Association.

million bushels was the lowest among the four states. Seven plants in Ohio processed 21.4 million bushels, averaging 3.1 million per plant; Indiana had four solvent plants, which processed 19.6 million bushels, or an average of 4.9 million per plant.

Although the 39 solvent plants in the four states represented only 20 percent of all the soybean processing plants in the 1951-52 crop year, the quantity processed by them represented slightly more than 60 percent of the total crush of the season, which clearly indicates the concentration of soybean processing in the four major soybean states.

During the 1951-52 season, 92 soybean processing plants, or nearly one-half of the total, were operating with the screw-press method, and 62 of these screw-press plants were located in the eight central soybean states (Illinois, Iowa, Ohio, Indiana, Minnesota, Missouri, Kansas, and Nebraska), the rest of the plants being scattered over the cotton belt. Compared to solvent plants, however, the total quantity processed and the average amount per plant were much smaller. The 45 screw-press plants in the four major soybean states represented about 23 percent of the total soybean processing plants in the United States, but accounted for only 15 percent of the soybeans processed in the season.

In the 1951-52 season there were 31 hydraulic method plants operating on soybeans in the United States, and 30 of these were in the cotton belt. Most of them were cottonseed oil plants which crushed soybeans after cottonseed supply had been exhausted. The total quantity processed by them was consequently quite small. The number of the hydraulic plants represented 16 percent of the total soybean processing plants, but their total crush accounted for only 1.4 percent of the soybeans processed during the crop year.

1954 situation.[1] By 1954, the total number of soybean processing plants in the United States increased to 261, of which 18 were hydraulic plants, 158 screw-press plants, and 85 solvent plants. Of the total number, 88 plants processed soybeans exclusively in 1954, which represents a sizable decline from the 128 plants of the 1951-52 season.

Of the 85 solvent plants, 57 were located in the four major soybean states, which indicates a higher concentration of solvent plants in these states than in the 1951-52 season. The 57 solvent plants represented only 22 percent of the total number of soybean processing plants in the United States, but they accounted for 78 percent of all the soybeans processed in 1954.

[1] *U.S. Census of Manufacturers,* 1954. The figures are based on the calendar year.

Ninety-five of the 158 screw-press plants were in the eight central soybean states. They represented 36 percent of the total plants operating on soybeans, but their crush amounted to only 5.2 percent of the total crush of the year. The remaining 63 screw-press plants were scattered mainly in the southern states and the quantity of soybeans processed by them was very small, accounting for only 0.8 percent of the total.

The number of hydraulic plants decreased by 1954 to 18 from 31 in the 1951-52 crop year. These plants were primarily cottonseed plants and their processing of soybeans was insignificant in terms of quantity.

1957-58 situation.[1] There was a considerable reduction in the number of soybean processing plants in the United States between the 1951-52 and the 1957-58 seasons. There were 139 active soybean processing plants in this latter year, and 87 of these operated on soybeans exclusively. The remaining 52 were primarily cottonseed and flaxseed oil plants which crushed soybeans after they had exhausted their supply of cottonseed or flaxseed.

During the 1957-58 crop year solvent plants accounted for 93 percent of the 354 million bushels of soybeans processed, and the balance of 7 percent was processed either by the screw-press or by the hydraulic method. More than half of the solvent plants were located in the four major soybean states, which accounted for about 69 percent of the total crush of 354 million bushels. As compared with the situation in 1954, the share of the total crush attributable to the solvent plants in the four states decreased by nearly 10 percent because of the increased number of solvent plants in other states, especially in Minnesota and some southern states.

In terms of quantity processed, the leading state was again Illinois which accounted for 34 percent of the total crush with its 20 processing plants. Iowa was the second, accounting for 16 percent with 23 plants; Ohio 10 percent with 9 plants; and Indiana 9 percent with 4 plants (Table 4).

As in the previous years, most of the hydraulic and screw-press plants were in the cotton-belt states.

Capacity and Mill Operations

It was pointed out earlier that until recently the soybean processing industry has always had a greater capacity than the soybeans available each year. Under the price levels of soybeans and soybean products

[1] *Capacity and Processing Trends in the Fats and Oils Industry,* Marketing Research Report 360, AMS, USDA, 1959.

Table 4. — Estimated Processing Capacity and Quantities of Soybeans Processed in Five Major Soybean States, 1951-52, 1957-58, and 1960-61

State	Plants		Total capacity[a]		Utilized capacity		Excess capacity		Ratio of utilized to total
	(number)	(percent)	(thousands of bushels)	(percent)	(thousands of bushels)	(percent)	(thousands of bushels)	(percent)	(percent)
United States									
1951-52	193[b]	100	310,498	100	242,842	100	67,656	100	78
1957-58	139[c]	100	453,353	100	353,769	100	99,584	100	78
1960-61[d]	146	100	N.A.		401,547	100			
Illinois									
1951-52	31	16	127,518	41	95,883	39	31,635	47	75
1957-58	20	14	135,867	30	120,343	34	15,524	16	89
1960-61[d]	19	13	N.A.		121,125	30			
Iowa									
1951-52	30	15	49,710	16	38,442	16	11,268	17	77
1957-58	23	17	64,918	14	56,435	16	8,483	9	87
1960-61[d]	22	15	N.A.		67,703	17			
Ohio									
1951-52	14	7	29,835	10	27,153	11	2,682	4	91
1957-58	9	7	41,846	9	34,642	10	7,204	7	83
1960-61[d]	5	3	N.A.		33,596	8			
Indiana									
1951-52	10	5	25,282	8	23,679	10	1,603	2	94
1957-58	4	3	36,224	8	31,298	9	4,926	5	86
1960-61[d]	5	3	N.A.		37,473	9			
Minnesota									
1951-52	7	4	11,979	4	10,325	4	1,654	3	86
1957-58	9	7	35,626	8	26,257	7	9,369	9	74
1960-61[d]	8	5	N.A.		26,593	7			
All others									
1951-52	101	53	66,174	21	47,360	20	18,814	27	72
1957-58	74	53	138,872	31	84,794	24	54,078	54	61
1960-61[d]	87	60	N.A.		115,057	29			

[a] For 1951-52, capacity is based on 11-month crushing season; 1957-58 on 12-month crushing season and month of biggest crush for each plant.
[b] Includes 128 plants which crushed soybeans exclusively, and 65 plants which crushed both soybeans and other oilseeds.
[c] Includes 87 plants which crushed soybeans exclusively, and 52 plants which crushed both soybeans and other oilseeds.
[d] Number of plants based on the directory of soybean processors in *The Soybean Blue Book*, 1961. The amount processed in each state based on figures published in the monthly issue of *The Soybean Digest*.

Source: 1951-52 based on *Processing the Three Major Oilseeds.* Marketing Research Report No. 58, AMS, USDA, April 1954, p. 11; 1957-58 based on *Capacity and Processing Trends in the Fats and Oils Industry*, Marketing Research Report No. 360, AMS, USDA, September 1959, p. 13.

that have so far prevailed, the capacity of the industry has never been utilized to the full extent, although nearly 80 percent of capacity is a fairly high rate of plant operation when we consider the necessary repairs.

We can note from Table 4 that the industry average rate of capacity utilization did not change between 1951-52 and 1957-58. During this period only Illinois and Iowa had a decrease in excess capacity, while Minnesota and the southern states increased their capacity a great deal. In terms of the actual amount of soybeans processed, Illinois' share of the total declined most: from 39 percent in 1951-52, to 34 percent in 1957-58. In the same period Minnesota and the southern states increased their share of the total crush. In more recent years Illinois' share has become smaller while the southern states have been expanding their soybean processing operations. It seems that this trend will continue in the future.

Cost Analysis of Soybean Processing

In order to understand the production economics of soybean processing and its effects upon development of the industry it is necessary to analyze (1) the production economics of different processing methods, (2) the economies of scale in the industry, and (3) the effects of these economic characteristics upon the development of the industry.

Yields and Processing Costs by Types of Operation

A trend toward solvent extraction has been one of the major characteristics of the soybean processing industry in the postwar period. This is the result primarily of the economic advantages accruing from the increased recovery of oil by solvent extraction as compared with mechanical methods.

Table 5 shows the advantage of solvent extraction over the other methods in terms of combined value of oil and meal obtained from a bushel of soybeans, based on the assumption that the same price is paid for soybean products manufactured by the different methods. This advantage in terms of value changes directly in relation to the price ratio of soybean oil and meal, if we assume that the processing cost is the same for the different methods. (Cost analysis will follow the present discussion.) However, as long as the price per pound of oil is higher than the price per pound of meal, solvent extraction can be said to be superior to the other two methods.

Table 5. — Yields of Oil and Meal by Method of Processing, and Combined Value of Products from a Bushel of Soybeans

Crop year	Price of products		Hydraulic press			Screw press			Solvent extraction			Additional value obtained with solvent extraction over	
			Yields[c]		Combined value of oil and meal	Yields[c]		Combined value of oil and meal	Yields[c]		Combined value of oil and meal		
	Oil[a]	Meal[b]	Oil	Meal		Oil	Meal		Oil	Meal		Hydraulic	Screw press
	(cents)		(pounds)		(dollars)	(pounds)		(dollars)	(pounds)		(dollars)	(cents)	
1947-48	23.8	4.08	8.46	48.54	3.99	8.86	48.14	4.07	10.67	46.33	4.43	44	36
1948-49	13.1	3.29	8.67	48.33	2.73	9.16	47.84	2.77	10.94	46.06	2.95	22	18
1949-50	12.3	3.22	8.38	49.52	2.63	8.96	48.94	2.68	10.73	47.17	2.84	21	16
1951-52	11.4	4.11	8.39	49.16	2.98	8.57	48.98	2.99	10.52	47.03	3.13	15	14

[a] Spot price per pound of crude oil, tank cars, f.o.b. midwestern mills.
[b] Spot price per pound of meal, bulk, Decatur, Ill. (41 percent protein before July 1950, 44 percent thereafter).
[c] Yields based on reports of the Bureau of the Census and the Production and Marketing Administration, USDA.

Table 6. — Price Ratio of Soybean Oil to Meal, Averages 1931-35, 1936-40, 1941-45, and Annual 1946-60 Crop Years

Crop year	Price of oil[a]	Price of meal[b]	Price ratio
	(cents)	(cents)	(oil price/ meal price)
1931-35 average	5.8	1.40	4.14
1936-40 average	6.3	1.50	4.20
1941-45 average	11.7	2.50	4.68
1946-47	23.3	3.56	6.54
1947-48	23.8	4.08	5.83
1948-49	13.1	3.29	3.98
1949-50	12.3	3.22	3.82
1950-51	18.1	3.21	5.64
1951-52	11.4	4.11	2.77
1952-53	12.1	3.40	3.56
1953-54	13.5	3.90	3.46
1954-55	11.9	3.03	3.93
1955-56	12.6	2.62	4.81
1956-57	12.7	2.37	5.36
1957-58	10.8	2.67	4.04
1958-59	9.5	2.79	3.41
1950-60	8.3	2.78	2.99
1960-61	11.3	3.03	3.73

[a] Cents per pound of soybean oil, crude, average price in tank cars at midwestern mills as reported by AMS, USDA.
[b] Cents per pound of soybean meal, 41 percent protein prior to July 1950, thereafter 44 percent protein, average wholesale price, bulk, at Decatur, Ill., as reported by AMS, USDA.

As can be seen from Table 6, the price ratio of soybean oil to meal had been extremely favorable for solvent extraction during and immediately after the war, which had naturally encouraged construction of solvent extraction facilities or conversion of the mechanical process to more efficient solvent extraction. What had actually happened during those favorable years is that because of the increasing demand for fats and oils and proteins the new solvent facilities had been added to the existing screw-press and hydraulic capacities to increase production. The additional solvent facilities after 1942 did not replace the expeller facilities, but were added to them until about 1948, when keener competition in the industry began to promote replacement of the mechanical process with solvent extraction. Even then it was most likely that many plants retained their screw-press facilities for several more years before they decided to dismantle them completely.

Processing cost of different types of operation. We cannot determine the economic advantages of solvent extraction without making a comparative study of processing costs by the different types of operation. Although three methods of processing have been in use in the soybean industry, the hydraulic method has accounted for such a small percentage of the total crush of soybeans that its cost structure is a minor factor in making a cost analysis of the industry. For this reason it is not included in our study.

According to the survey report published by the U.S. Department of Agriculture in May 1954, entitled "Processing Costs of Soybean Oil Mills, 1951-52 and 1952-53," the total costs of processing soybeans at solvent extraction plants, including costs of acquisition, transportation, current operating fixed and general costs, and sales and package costs, averaged 36.5 cents during 1951-52, whereas the costs at screw-press mills averaged 34.4 cents (Table 7). During the 1952-53 season, the total costs averaged 37.6 cents and 32.8 cents a bushel, respectively. Processors operating solvent extraction and screw-press mills as combined operations had relatively high average total costs of processing soybeans — 36.3 cents in 1951-52, and 38.0 cents in 1952-53.

A schedule of the costs of processing soybeans was developed jointly by the National Soybean Processors Association and representatives of the U.S. Department of Agriculture. The response to this cost schedule provided a sample covering approximately 45 percent of the total number of the soybean mills. It covered 60 percent of the total soybeans processed in the U.S. in 1951-52, and 62 percent of the soybeans processed in 1952-53. The returns provided substantial representation of all important segments of the industry, both screw-press and solvent extraction mills, including a wide range in annual volume of soybeans processed. The sample was composed of 37 percent screw-press mills, 46 percent solvent extraction mills, and 17 percent combined screw-press and solvent extraction mills in 1951-52; and 26 percent screw-press mills, 65 percent solvent extraction mills, and 9 percent combined mills in 1952-53. The solvent extraction mills processed 83 percent of the soybeans reported in the survey in the 1951-52 season and 91 percent in 1952-53. Screw-press mills processed 17 percent in 1951-52 and only 9 percent in 1952-53.[1]

Table 7 indicates that the acquisition cost of solvent mills and screw-press mills is about the same. Acquisition cost is composed of freight, trucking cost, and other acquisition cost; freight is usually referred to in the industry as freight loss. Freight loss for solvent mills was 0.9 cent higher in 1951-52, and 1.8 cents higher in 1952-53, than that for screw-press mills, but trucking cost averaged about 1 cent a bushel lower for solvent plants.

[1] *Processing Costs of Soybean Oil Mills, 1951-52 and 1952-53,* AMS, USDA, May 1954, p. 2.

Table 7. — Processing Costs per Bushel of Soybeans by Type of Operation, 1951-52 and 1952-53

Processing cost	Solvent extraction		Screw press		Combination		Average	
	1951-52	1952-53	1951-52	1952-53	1951-52	1952-53	1951-52	1952-53
				(cents)				
Acquisition								
Freight loss	3.2	3.1	2.3	1.3	2.2	2.1	2.9	3.0
Trucking	.4	.4	1.4	1.9	.1	.3	.5	.5
Other	.7	.8	.5	.4	.2	.3	.6	.7
Total	4.3	4.3	4.2	3.7	2.5	2.7	4.0	4.1
Current, fixed, and general:								
Current operating								
Labor	6.1	6.2	5.1	5.8	5.7	5.9	5.9	6.2
Power and light	1.3	1.5	2.4	2.2	1.6	2.4	1.5	1.6
Fuel and steam	2.1	2.1	1.4	1.5	2.1	.9	2.0	1.9
Water	.1	.1	.02	.04	.1	.1	.07	.08
Maintenance and repair	1.5	1.5	2.4	1.8	2.2	2.6	1.7	1.6
Solvent	1.1	1.2	.0	.0	1.0	1.6	1.1	1.3
Mill and elevator sundry expense	1.0	.9	.4	.4	.6	.4	.9	.9
Storage, rented	2.2	2.9	2.3	.6	2.3	2.1	2.2	2.6
Other mill expense	.3	.2	.1	.1	.2	.5	.3	.2
Total	15.6	16.6	14.3	12.5	15.6	16.6	15.5	16.3
Fixed and general								
Salaries	2.5	2.6	2.5	2.7	3.1	4.0	2.6	2.7
Depreciation	2.9	3.2	1.8	2.2	4.1	4.0	2.9	3.2
Interest and exchange[a]	1.5	2.0	1.7	1.9	2.1	2.2	1.8	2.1
Insurance	.4	.4	.5	.7	1.0	.9	.5	.5
Licenses and taxes[b]	.8	.8	.8	.9	.7	.6	.8	.8
Office	.4	.4	.7	.5	.4	.2	.4	.4
Travel and auto	.1	.1	.1	.1	.4	.5	.2	.1
Administrative	2.7	2.6	1.2	1.1	.7	1.0	2.3	2.4
Other	.3	.4	.3	.4	.1	.2	.3	.4
Total	11.7	12.8	10.1	11.2	12.5	14.2	11.6	12.8
Total current and fixed and general	27.3	29.4	24.4	23.8	28.1	30.8	27.0	29.0
Sales and package								
Brokerage	.7	.8	.7	.6	1.3	1.9	.8	.9
Bags, tags, etc.	3.3	2.4	5.0	4.6	4.3	2.5	3.7	2.6
Other selling expense	.9	.8	.04	.1	.2	.1	.6	.7
Total	4.9	4.0	5.8	5.3	5.7	4.6	5.2	4.2
Total processing cost	36.5	37.6	34.4	32.8	36.3	38.0	36.2	37.3

[a] Interest on borrowed capital, including interest on working capital.
[b] Except federal income tax.
Source: *Processing Costs of Soybean Oil Mills, 1951-52 and 1952-53*, AMS, USDA, May 1954, pp. 10-15.

In current operating expenses, solvent mills had higher cost for labor, fuel and steam, solvent (which is not used at all in the screw-press process) and mill and elevator sundry expense, while screw-press mills had higher cost for power and light and maintenance. In the category of fixed and general cost, the depreciation and administrative expenses of solvent mills were higher than those of screw-press mills. Solvent plants had an average total current and fixed and general cost of 27.3 cents a bushel in 1951-52, and 29.4 cents in 1952-53, which is slightly higher than the corresponding cost of 24.4 and 23.8 cents for screw-press mills. The lower average total current and fixed and general cost for screw-press mills in 1952-53 season as compared with 1951-52 is due to the fact that it was the lower-cost screw-press mills that continued to operate in 1952-53.

Solvent plants had a somewhat lower cost of bags and tags than did screw-press mills. However, the average percentage of meal sold in bags by solvent extraction mills was 36 percent, as compared with an average of 70 percent for screw-press mills. Solvent plants showed a higher cost for brokerage and other selling expense.

It can also be seen from Table 7 that those soybean processors who continued to operate their screw-press mills after building solvent extraction plants at the same locations had relatively high costs of processing both in 1951-52 and in 1952-53. Although those combination plants had lower acquisition costs than either solvent plants or screw-press mills, their higher costs in maintenance, salaries, depreciation, and interest and exchange had more than offset the advantage of lower costs of acquisition, resulting in relatively high total costs of processing per bushel. This would indicate that the practice of maintaining a screw-press operation to augment a solvent extraction operation was not very successful from a processing cost standpoint.

Economic advantage of solvent extraction. From the foregoing discussion it is apparent that the slightly higher processing cost of solvent extraction plants as compared with that of screw-press mills was more than offset by the advantage of higher recovery of oil. This accounts for the definite trend in the past toward the solvent extraction method in the soybean processing industry.

It is interesting to note that the result of the above USDA survey with respect to the difference of processing costs by type of operations is essentially in line with the wartime operating margins allowed soybean processors under the 1943-44 CCC processing contracts. The schedule of operating margins was as follows according to type and size of mills:

Type of operation	Daily capacity (bushels)	Operating margins allowed (cents per bushel)
Solvent		
Large	Over 6,000	29
Medium	3,000-6,000	30
Small	Under 3,000	31
Expeller and screw-press		
Large	Over 6,000	24
Medium	3,000-6,000	26
Small	Under 3,000	28
Hydraulic		
Large	Over 6,000	29
Medium	3,000-6,000	30
Small	Under 3,000	31

But our comparison so far has been in terms of averages of mills of all sizes and their processing costs in relation to value of products obtained from a bushel of soybeans. The result, therefore, does not tell us conclusively whether or not the advantage of solvent extraction over the screw-press method is valid for all sizes of mills, especially for small mills where investment per bushel of soybeans processed would be much higher for solvent plants due to the nature of the equipment. So the question now is a matter of comparative economies of small solvent and screw-mills. The answer to this question would not affect our conclusion based on the comparison of industry average figures because of the small quantities of soybeans processed each year by small plants, yet it would clarify the comparative advantage of solvent extraction for mills of all sizes.

In answer to the above question, another USDA study concludes that the screw-press mill was definitely more economical than the solvent mill at an annual capacity of 275,000 bushels and less primarily because of relatively lower investment and labor requirements per bushel of crushing capacity. On account of the relatively faster decline in capital and labor requirements, however, solvent mills became more economical than screw-press mills at approximately 550,000 bushels of crushing capacity per year, the advantage of the solvent mill at this point being over 1 cent per bushel and 2.5 cents per dollar of investment.[1]

[1] *Size of Soybean Oil Mills and Returns to Growers,* AMS, USDA, Marketing Research Report 121, pp. 34-35; data based on the 1952-53 season.

On the whole it is reasonable to say that the solvent method has a definite economic advantage over the screw-press method except in the case of very small mills, and this cost-revenue relationship can be said to have been the main motivation of the relatively rapid shift in the industry from the mechanical process to the solvent method. Although this comparison was based on the 1951-53 data, the analysis will hold true today as long as the technical aspects of the different methods of processing remain essentially the same and the price per pound of oil is higher than the price per pound of meal.

Economies of Scale in the Soybean Processing Industry

In the preceding section we have made a comparative study of the different processing methods on the basis of average processing costs in relation to the value of products obtained. Obviously the averages of mills of all sizes do not explain the variations of processing costs within the industry according to size of mill, and it is now proposed to study these variations and examine characteristics of economies of scale in the soybean processing industry.

Because of the nature of the available data, our investigation of cost structure in the soybean processing industry is in terms of the average costs for plants of different capacities, and the competitive advantage of large as compared to small units. From whatever source they may arise, all separable factors pertaining to economies and diseconomies in the industry are examined in this analysis.[1]

As shown in Table 8, there is a strong inverse relationship between processing costs and volume of soybeans processed each season, suggesting the existence of economies of scale in soybean processing operations.[2] It is apparent from the tables, assuming the mills had an equal rate of operation, that solvent plants had their highest per bushel processing costs in their lowest annual volumes.

The highest total cost of processing by the solvent method was for mills processing one million bushels or less per season. The cost averaged 42 cents a bushel in 1951-52, and 49 cents a bushel in 1952-53. In both seasons the processing cost decreased as the annual volume increased, and it reached the lowest level for plants processing 3,500,001

[1] Our analysis is based on the data presented in the two USDA publications: *Processing Costs of Soybean Oil Mills, 1951-52 and 1952-53, op. cit.; Size of Soybean Oil Mills and Returns to Growers, op. cit.*

[2] Data did not refer directly to the relationship between cost and sizes of mills because they were given in terms of cost and volume of soybeans processed, but they may be used to approximate the returns to scale.

Table 8. — Average Costs per Bushel (Cents) for Processing Soybeans at Solvent Extraction Mills, by Volume, 1951-52 and 1952-53

Processing cost	Bushels processed per mill during season: 1,000,000 and under	1,000,001 to 2,000,000	2,000,001 to 3,500,000	3,500,001 to 5,000,000	5,000,001 and over	Average of all solvent mills
			(1951-52)			
Acquisition						
Freight loss	3.7	1.3	2.9	3.0	3.5	3.2
Trucking	2.6	2.2	.8	.1	.02	.4
Other	.1	.9	.7	.7	.7	.7
Total	6.4	4.4	4.4	3.8	4.3	4.3
Current, fixed, and general:						
Current operating						
Labor	8.7	7.7	6.1	5.4	6.0	6.1
Power and light	1.3	1.5	1.8	1.1	1.2	1.3
Fuel and steam	2.5	3.6	2.1	1.7	2.0	2.1
Water	.02	.004	.03	.1	.1	.1
Maintenance and repair	1.8	2.0	1.6	1.6	1.3	1.5
Solvent	1.4	.9	.8	1.0	1.3	1.1
Mill and elevator sundry expense	.6	1.1	.6	.9	1.2	1.0
Storage, rented	...	.3	3.5	1.3	2.2	2.2
Other mill expense	.2	.001	.1	.02	.5	.3
Total	16.6	16.6	16.7	13.0	15.9	15.6
Fixed and general						
Salaries	4.7	2.1	1.9	1.9	2.8	2.5
Depreciation	4.0	5.1	2.8	2.8	2.6	2.9
Interest and exchange[a]	2.1	1.6	2.3	.8	1.3	1.5
Insurance	2.1	.7	.4	.3	.3	.4
Licenses and taxes[b]	1.0	1.4	.9	.9	.6	.8
Office	.7	.2	.3	.2	.5	.4
Travel and auto	.3	.1	.1	.03	.2	.1
Administrative	...	4.6	2.0	4.2	2.3	2.7
Other	.7	.5	.3	.5	.2	.3
Total	15.4	16.2	12.0	11.6	10.8	11.7
Total current and fixed and general	32.0	32.8	28.7	24.6	26.7	27.3
Sales and package						
Brokerage	1.1	.7	.9	.7	.6	.7
Bags, tags, etc.	1.7	3.4	3.2	2.6	3.7	3.3
Other selling expense	.3	.2	.6	.9	1.1	.9
Total	3.1	4.3	4.8	4.2	5.4	4.9
Total processing cost	41.5	41.5	37.9	32.5	36.3	36.5
Total soybeans processed (bu.)	2,651,568	5,782,702	24,876,440	17,121,853	51,088,016	101,520,579
			(1952-53)			
Acquisition						
Freight loss	4.5	1.6	2.7	3.0	3.7	3.1
Trucking	1.7	1.8	.6	.1	.04	.4
Other	.1	.7	.7	.7	.9	.8
Total	6.3	4.1	4.0	3.8	4.6	4.3
Current, fixed, and general:						
Current operating						
Labor	9.1	8.8	6.2	5.0	6.3	6.2
Power and light	1.8	1.4	2.1	1.2	1.2	1.5
Fuel and steam	1.8	2.3	1.8	2.1	2.2	2.1
Water	.2	.04	.1	.1	.1	.1
Maintenance and repair	2.4	1.5	2.0	1.6	1.1	1.5
Solvent	2.4	1.1	1.2	1.0	1.3	1.2
Mill and elevator sundry expense	.9	.8	.7	.7	1.2	.9
Storage, rented	.6	1.8	2.9	2.9	3.2	2.9
Other mill expense	.5	.04	.06	.1	.4	.2
Total	19.4	17.8	17.1	14.7	17.0	16.6
Fixed and general						
Salaries	4.4	2.5	2.4	1.9	3.0	2.6
Depreciation	4.2	5.8	3.0	2.6	3.2	3.2
Interest and exchange[a]	3.4	2.6	2.6	1.8	1.6	2.0
Insurance	2.1	.9	.5	.4	.3	.4
Licenses and taxes[b]	1.0	1.1	.7	.8	.8	.8
Office	.8	.6	.3	.4	.5	.4
Travel and auto	.3	.1	.1	.1	.2	.1
Administrative	2.0	4.5	2.0	2.9	2.4	2.6
Other	.6	.9	.4	.5	.3	.4
Total	19.0	18.9	12.2	11.9	12.2	12.8
Total current and fixed and general	38.5	36.7	29.3	26.7	29.3	29.4
Sales and package						
Brokerage	.8	1.0	1.1	.8	.6	.8
Bags, tags, etc.	3.5	4.4	1.8	2.1	2.6	2.4
Other selling expense	.1	.4	.3	.7	1.3	.8
Total	4.4	5.8	3.2	3.6	4.5	4.0
Total processing cost	49.1	46.6	36.5	34.1	38.3	37.6
Total soybeans processed (bu.)	4,022,942	8,078,239	31,495,550	32,120,786	47,533,395	123,250,912

[a] Interest on borrowed capital, including interest on working capital.
[b] Except federal income tax.
Source: *Processing Costs of Soybean Oil Mills, 1951-52 and 1952-53*, AMS, USDA, May 1954, pp. 11-12.

to 5,000,000 bushels a year. As the volume increased beyond 5,000,000 bushels, the total processing cost also increased by about 4 cents per bushel both in 1951-52 and in 1952-53. All major cost groups of mills with an annual volume of 5,000,001 or over, with the exception of the fixed and general cost in 1951-52, are higher than those of mills processing 3,500,001 to 5,000,000 bushels per season. Among major cost items, freight loss, labor, salaries, and depreciation (1952-53) showed increases.

It cannot be known from the survey data alone whether the economies of scale in soybean processing are limited to mills having an annual volume of 5,000,000 bushels or less, because sufficient data were not included regarding the cost structure of mills processing more than 5,000,000 bushels per season.

However, a USDA study can give us further information on this subject. This study, entitled *Size of Soybean Oil Mills and Returns to Growers,* sought to determine the way in which change in the size of solvent soybean oil mills under typical operating conditions is related to corresponding change in total cost and total revenue per bushel of soybeans processed. To place all mills on a comparable basis with respect to depreciation, interest, property taxes, and insurance, model mills were developed through the use of engineering methods. Operating requirements and practices of these model mills were checked for reasonableness against those of well-operated actual mills. These models were assumed to be operating under average conditions with respect to costs per unit of input, transportation cost of soybeans, the proportions of bulk and bagged meal produced, and f.o.b. mill returns for oil and meal. It was also assumed that they operated at normal daily processing rates and for a 12-month season of 330 24-hour working days.

The results of the study are shown in Table 9. The table shows that (1) the size of solvent mill increased from an annual volume of 275,000 bushels to 11,000,000 bushels, while the total cost of processing, including acquisition cost of soybeans, decreased from 63 cents per bushel to 35 cents per bushel; (2) with three minor exceptions the total cost declined with each increase in size of mill but at a decreasing rate; (3) the individual costs which declined most as a percentage of the total cost were plant, labor, and meal bags, while the individual costs which increased most rapidly as a percentage of the total cost were soybean acquisition and general administrative expense; and (4) the percentage relationships of other individual costs to the total cost remained relatively stable for different sizes of mills.

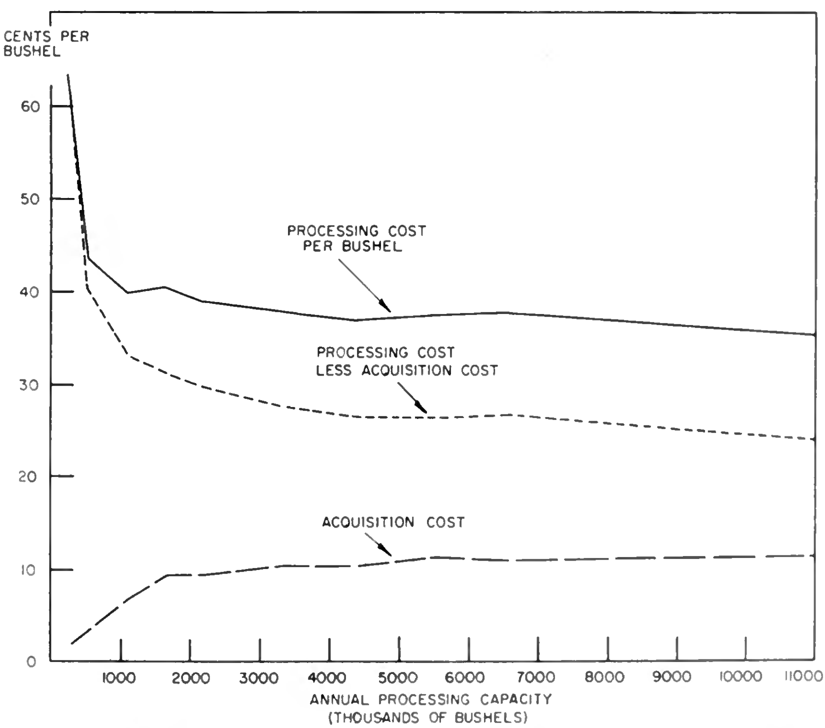
Table 9. — Distribution of Processing Costs, Solvent Oil Mills by Size of Mill, 1952-53 Season

Size of mill[a]		Processing cost per bushel of soybeans	Distribution of processing cost											
Annual capacity	Daily capacity		Soybean acquisition[b]	Plant[c]	Labor	Electricity and fuel oil	Solvent	Meal bags	Maintenance and repair	Salaries	General administration	Working capital	Selling expense	Other[d]
(thousands of bushels)	(tons)	(cents)	(percent)											
275	25	63.51	3	33	23	9	3	13	3	6	1	3	1	2
550	50	43.92	8	29	16	8	3	13	4	9	3	3	2	2
1,100	100	39.98	17	23	13	9	3	9	4	9	4	4	3	2
1,650	150	40.42	23	20	12	9	2	8	3	8	5	4	3	3
2,200	200	38.98	24	19	12	8	2	7	3	8	6	4	4	3
3,300	300	37.97	27	17	10	8	2	7	3	7	8	4	4	3
4,400	400	36.88	28	16	10	8	2	6	3	7	9	4	4	3
5,500	500	37.47	30	15	10	8	2	6	3	6	10	4	4	2
6,600	600	37.69	29	17	9	8	2	6	3	6	10	4	4	2
8,800	800	36.37	31	15	8	8	2	6	3	6	11	4	4	2
11,000	1,000	35.11	32	14	8	8	2	5	3	7	10	4	5	2

[a] Annual capacity at 330 days per year.
[b] Acquisition cost includes (1) charges for handling soybeans by country elevators and other intermediaries and (2) transportation costs on soybeans delivered to mill.
[c] Includes depreciation, interest, taxes, and insurance.
[d] Includes water, laboratory services, insurance on stocks, and welfare risks.
Source: *Size of Soybean Oil Mills and Returns to Growers,* Marketing Research Report 121, AMS, USDA, November 1956, p. 26.

In the light of the background theory for short-run and long-run cost-curve concepts, we can show diagrammatically the way in which change in the size of mill may be related to variation in the total cost of processing. But in order to do this a few simplifying assumptions have to be made about the data. It must be assumed that the cost-size relationships indicated by the model plant data represent points on short-run cost curves for different levels of plant capacity and that these points approximate the points of tangency of short-run cost curves with the long-run cost curve. Then the cost-size relationships can be illustrated by diagrams, as shown in Fig. 1.

These assumptions are probably reasonable because the cost-size relationships obtained by the model plant study indicate low points on respective short-run cost curves since all sizes of mills in the study were assumed to run a 12-month season (or 330 working days) and have no unutilized capacity. The model plant costs are lower than the costs obtained from the survey data when we compare them on the same basis of acquisition cost.



Processing costs of solvent extraction plants by size in 1952-53. (Fig. 1)

In terms of the total processing costs, including acquisition cost, economies of scale are most apparent when capacity increased from 275,000 bushels to 1,100,000 bushels per year, after which a trend of slow decline continued as capacity increased. It is interesting to note that a low point is reached somewhere between 3,300,000 and 5,500,000 bushels capacity, although plants of much larger capacity show a further decline in processing cost. This finding of the USDA study, based on the model mills, corresponds to the finding of the previous USDA study which was based on the data of the National Soybean Processors Association.

A solvent mill with an annual capacity of 6.6 million bushels shows a higher cost than a mill of 4.4 million bushels, due mainly to the increased cost of acquiring soybeans and increased cost of general administration and selling expense, which are not offset by large enough decreases in other costs, particularly plant costs such as depreciation, interest, taxes, and insurance. In plants of higher capacity than 8,800,000 bushels, the decreases in plant operating costs more than offset the slight increase in cost of acquisition and selling.

Processing cost, however, exclusive of acquisition cost, shows a clear trend of economies of scale. This is a good indication that as far as processing technology is concerned there exist definite economies of scale in soybean processing operations.

Thus theoretically there must be an equilibrium point between internal economies of scale in processing and external diseconomies of geographical dispersion of business activities to result in an optimum size of producing unit. Also there could be a multiple of near-equilibrium points or near-optimum sizes of plant over a wide range of processing capacity depending upon interrelationships between internal economies of production and external diseconomies of distance. Fig. 1 indicates that such points may probably be located in the vicinity of the annual capacity of 1,100,000; 4,400,000; and possibly somewhere around 11,000,000 bushels for solvent mills.

Internal economies of scale are largely a technical problem associated with processing and handling of soybeans and soybean products, while external diseconomies of distance are a matter of locational factors, largely the cost of transporting soybeans and soybean products. Under competitive conditions this latter cost imposes limitation on the size of any single processing unit, although no optimum size limit is ascertainable from either of the two USDA studies. These studies, which are based on different types of data, show that there exist economies of scale in soybean processing, and that over an annual capacity of 1,000,000 bushels economies of scale are not a simple trend of descent, but have a few low points at an interval of several million bushels, declining very slowly as a whole.

Changes in Levels of Processing Costs

The absolute levels of processing costs change over time reflecting changes in cost of items comprising the total. But as long as the basic processing technology remains unchanged the conclusion we have reached in the above analysis also remains valid.

Now we shall briefly examine changes in general levels of processing costs in recent years. One definite limitation in this attempt is the quantity and quality of available data. As already shown, processing costs differ widely according to size and type of mill. Different estimates are generally based on different original costs of installation, depreciation schedule, etc., and therefore, strictly speaking they are not comparable on any common basis.

For the sake of simplicity and clarity, we shall take a 300-ton per day (3 to 3.3 million bushels per year) solvent plant for our study. Assuming that the available data are comparable with each other, we have shown four different estimates in Table 10. It can be immediately noted from the table that engineering firms tend to have very low estimates for the cost of labor, solvent, and maintenance necessary to run a processing plant, and this may be quite natural because their estimates are in terms of more or less ideal conditions for the processing equipment they design and manufacture. On the other hand, the USDA survey data represent a high average cost as compared with the other estimates. In the light of the 1952 USDA model plant study and later engineering estimates it appears that the 1951 survey data tended to overestimate the processing cost in the industry at that time.

Given this tendency on the part of equipment manufacturers, we may yet say that technical improvement in design and manufacture of solvent plant equipment in recent years has resulted in reduced cost of operation at plants built in the past several years. Older plants, on the other hand, have the advantage of lower depreciation cost. In addition, under competitive conditions less efficient plants have been forced out of business. Thus it can be said that the average level of processing cost in the industry has become somewhat lower, if not greatly lower, in recent years.

On the basis of the engineering estimate made in 1962 for a 300-ton per day plant, the present level of total processing cost in efficient

Table 10. — Changes in Levels of Processing Costs per Bushel of Soybeans

Processing costs	300 tons per day solvent plant (3,000,000-3,300,000 bushels per year)			
	USDA survey study (1951)[a]	USDA model plant study (1952)[b]	Engineering firm estimate (1956)[c]	Engineering firm estimate (1962)[d]
	(cents)			
Current operating				
Labor	6.1	4.0	3.4	2.1
Power and light	1.8	1.3	1.8	.6
Fuel and steam	2.1	2.0	2.4	1.1
Water	.03	.15	.09	...
Solvent	.8	.8	.3	.4
Maintenance, materials, and repairs	1.6	1.3	.7	.6
Total	12.4	9.6	8.7	4.9
Fixed and general				
Depreciation	2.8	2.4	2.2	2.9
Insurance	.4	.1	.2	.1
Taxes	.9	1.1	.5	.6
Miscellaneous	.3	.7	.4	...
Total	4.4	4.3	3.3	3.6
Total current and fixed and general	16.8	13.9	12.0	8.5
Acquisition cost	4.4	10.3(3.2)[f]	5.0[h]	5.0[h]
Sales and package	4.8	3.8	2.0[h]	2.0[h]
Other current and fixed and general cost	11.9[e]	10.6[g]	10.0[h]	10.0[h]
Total processing cost	37.9	38.0(30.9)[f]	29.0	25.5

[a] Based on Table 19 for a plant with an annual processing capacity of 2,000,001 to 3,500,000 bushels.
[b] Based on Table 20 for a plant with an annual processing capacity of 3,300,000 bushels.
[c] Estimates by an engineering firm which designs and manufactures oilseed processing equipment.
[d] Estimates by another engineering firm which designs and manufactures oilseed processing equipment.
[e] Includes mill and elevator sundry expense, storage and other mill expense, salaries, interest and exchange, office, travel and auto and administrative cost.
[f] Acquisition cost less country elevator and other intermediary handling charges.
[g] Includes interest, insurance on stocks, salaries, general administration and working capital.
[h] Cost assumed on the basis of the USDA survey study and model plant study of processing cost, with selling expense adjusted for bulk sale of meal.

plants would be somewhere between 25 cents and 30 cents per bushel for solvent plants with a capacity of around 300 tons per day.[1] Of this cost the most direct operating expense, including both current and fixed and general, would be about 9 to 10 cents per bushel. The variable cost of operation, including current operating cost, acquisition cost, and sales cost, would be 14 to 15 cents per bushel. Total fixed cost would be about 12 cents per bushel. The total operating expenses, exclusive of the acquisition and sales and package costs, would be about 18 cents per bushel at solvent plants.

Processing Costs and Revenue

Before we can evaluate various effects of economies of scale in soybean processing, we must consider the total costs of processing by size of mill in relation to revenues for different levels of capacity. In this way we can see the net effect of large-scale production. Although total processing costs per bushel vary inversely with size of plant, the cost of acquiring soybeans and selling products increases with size of mill. This is due to geographical dispersion of business activities. The same locational factors affect gross revenues or f.o.b. returns of mills of different sizes because the larger mills generally are not able to secure as high a total price for the end products as that obtained by the smaller mills who sell their products locally with less transportation and handling costs.

It may be reasonable to assume, as in the USDA model plant study, that oil revenue does not change appreciably according to size of mill, but meal revenue per bushel declines with increase in the size of mill. The question then is how decreases in meal revenue with increases in size of mill compare with decreases in cost per bushel of soybeans.

According to the model plant study of the USDA, the results of which are shown in Table 11, cost declined appreciably with increases in size of mill, while total revenue declined by approximately the same amount due to lower meal revenue. The increasing cost of transporting soybeans and soybean products offsets the benefit of economies of scale in processing operations. As a consequence, there was no appreciable relationship between sizes of mills and net revenues per bushel of soybeans processed.

[1] According to Table 9, a difference in processing cost between a 200-ton per day solvent plant and 800-ton per day plant is 2.6 cents per bushel. The estimate of 25 to 30 cents per bushel does not include elevation charges at country shipping points, but includes the average acquisition cost (freight loss and others) of 5 cents, and 2 cents for sales and package cost.

Table 11. — Calculated Costs and Returns of Solvent Soybean Oil Mills by Size of Mill, 1951-54 Average

Annual capacity of mill	Investment per bushel	Total cost per bushel[a]	Gross revenue per bushel[b]	Net revenue per bushel	Return per dollar of investment[c]
(thousands of bushels)		(dollars)		(cents)	
275	2.218	3.3750	3.3537	−2.1	−.9
550	1.375	3.1790	3.2797	10.1	7.3
1,100	.987	3.1400	3.2313	9.1	9.2
1,650	.910	3.1440	3.2103	6.6	7.3
2,200	.843	3.1300	3.1997	7.0	8.3
3,300	.717	3.1200	3.1893	6.9	9.6
4,400	.643	3.1090	3.1883	7.9	12.3
5,500	.641	3.1150	3.1800	6.5	10.1
6,600	.699	3.1170	3.1800	6.3	9.0
8,800	.625	3.1040	3.1730	6.9	11.0
11,000	.568	3.0910	3.1663	7.5	13.2

[a] Cost of soybeans plus processing cost.
[b] Combined value of oil and meal.
[c] After all cost, including interest on both fixed and working capital, whether owned or borrowed.
Source: *Size of Soybean Oil Mills and Returns to Growers*, AMS, USDA, Marketing Research Report 121, November 1956, Table 38.

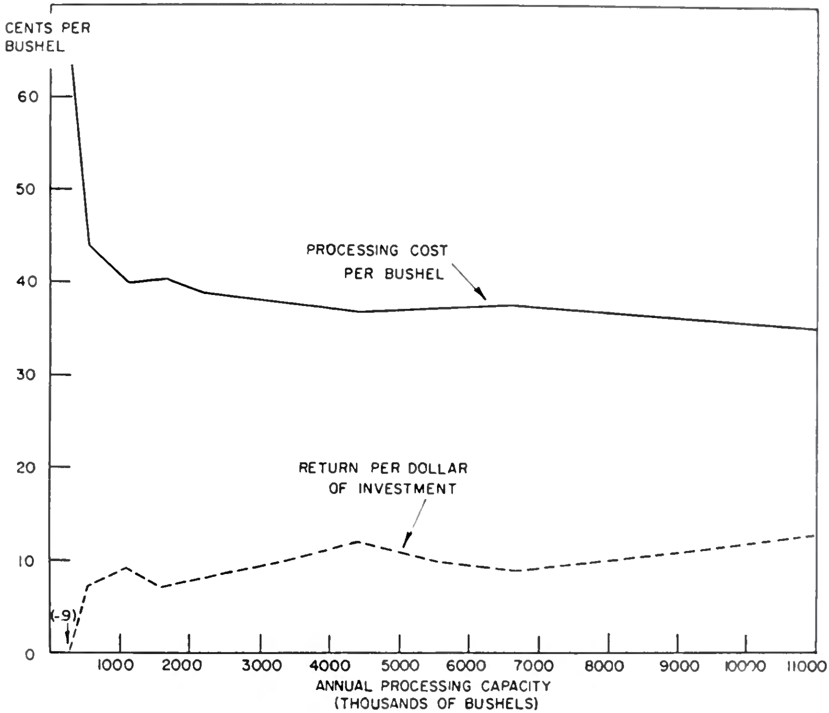
But in spite of the nearly uniform net revenue per bushel processed, the larger the mill the smaller its investment per bushel, and as a result, the greater was its return per dollar of investment. This is the real advantage of large-scale production in terms of monetary value. Larger mills could use this differential profit to bid up the price of soybeans until the net returns per dollar of investment fall to the level of smaller mills.

It is interesting to note, however, that the net return per dollar of investment is not a simple trend of ascent with increases in size of mill; it forms peaks at the levels of capacity which correspond to the low points of processing costs. These relative relationships between total processing costs and net returns per dollar of investment are shown in Fig. 2.

The above comparisons refer to solvent plants in the USDA study, but the conclusions should generally hold for screw-press mills because the effects of locational factors with respect to gross revenue for the end products are practically the same for both types of plants.

Effects of Economies of Scale

Economies of scale in soybean processing must logically indicate a trend in the industry for enlargement of production scale to the levels



Processing costs and return per dollar of investment for solvent extraction plants, by size in 1952-53. (Fig. 2)

of capacity where a net return from processing is maximized. This process may be seen in enlargement of individual plants where such expansion is financially possible or in consolidation by horizontal integration, resulting in higher concentration of ownership in the industry. In both cases processing efficiency will be raised by these enlargements of scale, and this will result in elimination of less efficient plants of smaller sizes. As shown in our preceding analysis, however, under competitive conditions there exist near-optimum levels of production in the lower range as well as in the higher range of capacity due to the locational factors. This should allow for existence of plants of various sizes in the industry, although it is apparent that as the competition has become keener in the industry it has become increasingly difficult for smaller mills to survive unless they are located so as to enjoy low freight costs for both soybeans and soybean products. This is likely to be the case in the marginal areas of soybean production where some quantities of soybeans are readily available and meal production can be consumed locally. Fundamentally, however, the trend should be toward plants with capacities as large as circumstances permit, and in fact, the trend for larger and fewer plants has been one of the major characteristics of the industry in its rapid development during the postwar period.

Another inference we could make from our cost study is that it would have been more economical for firms to develop as multi-plant organizations over wide geographical areas rather than to be super-size, single-plant units at one location. The horizontal multi-plant expansion over wide territory could have the benefits of lower transportation costs for both soybeans and products, although the cost of constructing a new plant might be somewhat higher than that of adding capacity to the existing facilities.

Our cost study has shown that the main negative forces in enlargement of scale in soybean processing were the cost of acquiring soybeans and of selling soybean products. Obviously in order to maximize net profit, processors must endeavor to minimize these transportation costs in their operations. On a given location of plant, however, little can be done about the cost of acquiring soybeans except to fully utilize the processing-in-transit privileges. Plants can further process meal into a higher value product of mixed feed with the addition of various other ingredients and then ship out manufactured feed fully utilizing the in-transit advantages on the meal portion of the product. Thus outgoing cost of meal disposal becomes smaller in terms of the revenue to processors, offsetting the adverse effect of meal disposal as crushing capacity increases. So, even if we disregard for the time being the attitude of feed manufacturers toward integration of soybean processing, it can be said that vertical integration of soybean processing with manufacturing of mixed feed based on soybean meal is an economical combination of business activities from the processor's point of view, although other factors are certainly at work for such integration. (The problem of integration will be discussed later.)

Analysis of Processing Margins

We shall now examine the various factors which determine processing margins and net returns in the soybean processing industry in an effort to clarify the motivating forces, characteristics, and trends in the industry, and to understand the competitive position of individual soybean processors.

Processing Margins for the Industry and Individual Mills

Definition of processing margins. Processing margins or crushing margins are generally defined as the spread between the value of soybean products per bushel of soybeans and the price the processor pays for his soybeans. It is not possible to determine the actual processing margins of a processor from published data alone since there are many variations in the factors affecting the margin.

The combined value of soybean oil and meal per bushel of soybeans differs widely from plant to plant depending upon the yields of these products and also the transportation and market conditions relating to sales of the products. The price paid by the processor for his soybeans varies considerably according to the location and size of the plant and buying practices of the processor. Moreover, generally processors do not buy soybeans and sell products simultaneously. They store soybeans and products and inevitably speculate in prices and price relationships, engage in manufacturing of mixed feeds or refining their oil, all of which affect the processing margins but are not available from existing data. The true margin is not the difference between the current value of the products and the current price of the soybeans, but the difference between the current value of the products and the price previously paid for the soybeans. However, over a period of time the two different calculations would give about the same average result.

Average processing margins for the industry can be estimated from published data of yield and price information, although we have to substitute the farm price of soybeans for the price paid by processors.[1] The processing margin thus estimated includes not only all the charges incurred between the farmer and the buyer of the oil and meal for transportation, processing, handling, financing, and whatever other services are required, but also the profit margin, either positive or negative, for the processor. The average processing margin, therefore, can be an approximate measure for estimating the profit situation in the industry as long as no basic change occurs in the processing technology.

Annual variations in the processing margins. By the definition of our term, the immediate determinants of the processing margin in the soybean industry are the prices of both soybeans and soybean products and the yields of oil and meal per bushel processed. Of these two

[1] In this study the price spread in this sense is also referred to as the processing margin. To approximate the actual price paid by processors, we must add a flat charge of 5 cents per bushel to the farm price of soybeans in Illinois and a little higher charge for other areas for elevation at country shipping points.

factors the prices are the more important determinant since the variations in yields are limited to a narrow range due to the physical characteristics of soybeans and the technology of soybean processing. It is not our concern here, however, to analyze the factors which determine these prices.[1] We are interested in the relative price relationships between soybeans and soybean products in the past and their effect upon the development and operations of the soybean processing industry in the United States.

In terms of annual averages for the industry, the relative price relationships between soybeans and soybean products have fluctuated a great deal, which in turn has resulted in wide variations of the apparent processing margin over the years. It can be observed from Table 12 that in the postwar years there has been a general trend for the processing margin to decline, but improvements in the marketing system for soybeans and soybean products, especially the expanded use of the futures market, have reduced the cost of risks borne by processors. Therefore, other things being the same, the processing margin in real terms would have tended to increase over the years for the industry as a whole.

The over-all efficiency of the industry is importantly related to the average processing margin. The improvement of productive efficiency in soybean processing under competitive conditions will bring about either a lowering of prices of the products or a raising of prices of soybeans paid to farmers or both, and this will directly affect the average processing margin in the direction of smaller magnitude. Technological developments and economies of scale are the important elements in promoting the over-all efficiency of the soybean processing industry.

In the past few years when soybean production has been sufficiently large for requirements in the processing industry and for other uses, and there have been large stocks of surplus oil, the government actions with respect to the price-support programs for soybeans and the surplus disposal programs for oil have affected the magnitude of the processing

[1] A number of studies are available on this subject: Paarlberg, Don, *Prices of Soybeans and Soybean Products;* Purdue Agr. Exp. Sta. Bul. 558, 1949; Jordan, G. L., *What Determines Soybean Prices,* University of Illinois Agr. Exp. Sta. Bul. 546, 1951; USDA Marketing Research Report 35, May 1953, Soybeans — economic analysis relating to processing, pp. 30-34; a series of articles entitled "Factors affecting soybean prices," *The Soybean Digest,* September 1960, pp. 65-74; Hieronymus, T. A., Soybeans and product prices for the 1961 crop, *The Soybean Digest,* September 1961, pp. 55-60; Hieronymus, T. A., Forecasting soybean meal futures prices, *Commodity Year Book,* 1961, pp. 20-31; West, V. I., Soybean and product outlook in 1962-63, *The Soybean Digest,* September 1962, pp. 45-49.

Table 12. — Price Spread Between the Value of Products per Bushel of Soybeans Crushed, and Farm Price of Soybeans, 1947-61

Crop year beginning October	Yield	Oil Price[a]	Value	Yield[b]	Meal Price[a]	Value	Total value	Soybean price		Spread between value of products and soybean price	
								Farm	No. 1 yellow Illinois points	Farm	No. 1 yellow Illinois points
	(pounds)			(pounds)							
1947	9.5	23.7¢	$2.25	46.4	4.04¢	$1.87	$4.12	$3.33	$3.66	$.79	$.46
1948	9.8	13.1	1.28	46.1	3.30	1.52	2.80	2.27	2.36	.53	.44
1949	9.9	12.3	1.22	47.0	3.22	1.51	2.73	2.16	2.52	.57	.21
1950	9.7	17.8	1.73	46.8	3.22	1.51	3.24	2.47	2.97	.77	.27
1951	10.0	11.3	1.13	4.67	4.17	1.95	3.08	2.73	2.97	.35	.11
1952	10.8	12.1	1.31	47.4	3.38	1.60	2.91	2.72	2.78	.19	.13
1953	11.0	13.5	1.48	47.4	3.93	1.86	3.34	2.72	3.26	.62	.08
1954	10.9	11.9	1.30	45.8	3.04	1.39	2.69	2.46	2.56	.23	.14
1955	11.1	12.5	1.39	46.2	2.63	1.21	2.60	2.22	2.51	.39	.10
1956	10.9	12.7	1.38	47.5	2.37	1.13	2.51	2.18	2.33	.33	.18
1957	10.7	10.8	1.16	46.8	2.67	1.25	2.41	2.07	2.19	.34	.22
1958	10.6	9.5	1.01	47.3	2.79	1.32	2.33	2.00	2.11	.33	.22
1959	11.0	8.3	.91	46.5	2.78	1.29	2.20	1.96	2.08	.24	.12
1960	11.0	11.3	1.24	47.0	3.03	1.42	2.66	2.13	2.55	.53	.11
1961	10.9	9.5	1.04	47.1	3.18	1.50	2.54	2.28	2.41	.26	.13

[a] Simple average price per pound using the following quotations: soybean oil, crude, tank cars, f.o.b. midwest mills; soybean meal, bulk, Decatur, quoted as 41 percent prior to July 1950, 44 percent beginning July 1950.

[b] Yield of meal not adjusted upward to include outturn as flour.

Source: *Fats and Oils Situation*, 1964 Outlook Issue, ERS, USDA, p. 21.

Remarks: The spread calculated in the table includes cost of moving soybeans through country elevators to processing plants.

margin. The minimum price paid by processors for their soybeans is dictated by the CCC loan levels, and prices of soybean oil are greatly affected by the P.L. 480 programs, which in turn affect the prices of soybean meal.

The loan level for soybeans tends to be set with political considerations and resists the lowering trend of prices resulting from increasing production of soybeans, while prices of soybean oil are depressed by large surplus stocks of oil even though the government export programs contribute to maintaining prices of oil above levels that would otherwise exist. Soybean meal cannot be priced too high if it is to be moved into consumption. Thus at present processors are experiencing a squeeze on their processing margins and their fate is closely related to the decisions of the government.

Seasonal variations in the processing margins. As prices of soybeans and soybean products fluctuate within a season these price changes cause variations in the average processing margins. The monthly variations of the average processing margins were calculated for the ten-year period of 1951 to 1960, as shown in Table 13.[1] The computed margins include cost of moving soybeans through country elevators to processing plants.

It is quite apparent that there is a wide variation in the average processing margin within a season and that there is a definite pattern in the seasonal variation. The margin is most favorable for processors in September and continues to be wide at the time of soybean harvest, after which it gradually narrows and reaches its lowest point in May. The September soybean price is generally heavily discounted by the forthcoming new crop. But the new crop does not affect the price of the September delivery oil and meal nearly as much, with the result that the processing margin in September is the widest of the year. During harvest the margin stays wide due to the selling pressure of the new crop of soybeans on the market. But as the soybean prices recover relative to product prices after harvest, the processing margin declines steadily until it reaches the lowest level in May, after which it takes an upward trend in line with the lowering trend of soybean prices.

[1] Margins computed on the basis of Decatur prices of oil and meal and U.S. average farm prices of soybeans have an upward bias in terms of the Illinois situation because of the lower U.S. average prices as compared with farm prices of soybeans in Illinois. For other areas these margins tend to have a downward bias due mainly to higher prices of meal in locations away from Decatur. But for our present purpose the margins in Table 13 are considered appropriate.

Table 13.—Average Processing Margins for the Soybean Industry, Monthly and Season Average, 1951-60, Cents per Bushel of Soybeans Processed[a]

Crop year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Season average
1951-52	47.7	24.4	10.8	4.2	1.1	−3.1	14.6	31.0	29.9	33.1	59.4	52.7	34.6
1952-53	38.8	28.9	32.1	26.5	25.6	23.9	19.9	13.9	14.7	23.9	28.5	37.8	18.8
1953-54	38.6	28.0	26.7	24.9	21.0	25.9	31.9	10.2	14.9	31.6	52.6	55.9	62.9
1954-55	27.9	29.5	34.3	27.1	20.3	13.4	19.4	19.0	26.8	29.1	29.5	54.5	22.7
1955-56	39.9	26.6	22.9	20.9	30.5	30.0	24.8	11.1	6.5	20.7	19.7	26.8	38.7
1956-57	35.6	31.1	35.8	41.6	37.1	25.6	19.5	13.7	16.9	18.5	23.2	29.9	33.1
1957-58	27.3	25.2	17.3	19.0	25.8	34.1	41.2	36.7	29.4	60.5	38.0	48.7	33.5
1958-59	32.8	49.1	46.4	48.3	21.6	22.4	20.5	14.3	22.8	33.9	32.9	30.0	32.7
1959-60	34.1	23.2	24.1	16.7	16.7	12.0	17.9	15.7	22.4	22.3	25.4	30.9	24.4
1960-61	23.7	19.8	30.7	26.1	29.2	26.4	15.7	9.1	19.1	26.7	34.2	32.5	53.7
10-year average	34.6	28.6	28.1	25.5	22.9	21.1	22.5	17.5	20.3	30.0	32.3	40.0	35.5

[a] Calculations done in the same manner shown in Table 12. Figures usel are taken from *The Soybean Blue Book*, 1962, p. 42.
Note: The processing margins shown in the table include cost of moving soybeans through country elevators to processing plants.

Determination of processing margins for individual mills. Essentially the same factors mentioned in the preceding paragraphs as affecting the average processing margin for the industry are also at work to determine the processing margin for individual mills.

Undoubtedly the proximity of any specific mill to the area of soybean production and the markets for the products, including export outlets, is the single most important factor affecting the processing margin or the competitiveness of that mill in relation to other mills in the industry. The freight structures of transportation by railroad, water, and truck are the major aspect of the locational factors.

Another factor which importantly affects the prices paid for soybeans and received for the products by individual mills is the ability or level of management. The timing of purchase of soybeans and sale of the products directly determines the processing margin under which individual mills operate. For an individual mill with a given cost structure, maximizing the processing margin is maximizing net returns.

A third important factor affecting the processing margin of individual mills is the quality of soybeans, especially variation in oil content of soybeans. The yield of crude oil is determined by the oil content of the soybean seed, while the yield of soybean meal per bushel of soybeans processed depends primarily on the oil content of soybeans. The higher the oil content, the smaller the quantity of meal produced. Climate, in particular the temperature during the growing season, and inherent characteristics of the different varieties, are considered to be the major causes for variation of oil content in soybeans.[1] In fact, oil content varies from year to year and from area to area, and as such affects the annual average yields of oil and meal in processing. This in turn influences the processing margins of individual mills, although only to a very limited extent.

The yield of oil and meal is affected also by the percentage of foreign material and moisture content in a bushel of soybeans. These quality factors are related to the loss in processing which again varies from year to year and from area to area depending upon the general quality of soybeans produced.

In his study of the effect of other quality factors upon the value of the products, V. I. West at the University of Illinois found in data from the 1948 and earlier crop years that (1) splits and test weight

[1] A detailed discussion on this subject can be seen in a USDA publication: *Marketing Study of Factors Affecting the Quantity and Value of Products Obtained from Soybeans,* Production and Marketing Administration, Fats and Oils Branch, June 1952.

are not important determinants of value, and (2) the relationship between oil yield and percent of damage is sometimes positive and sometimes negative, hence no generalizations can be made for the soybeans classified as damaged under current procedures.[1] Similar results were obtained in the USDA analyses based on the 1949 and 1950 crops of soybeans.[2]

Under the present system of grading and discount in the industry, the quality factors such as test weight, moisture, splits, damaged kernels, and foreign materials, affect the prices of soybeans paid by processors, although the important quality factor of oil content is not included in the present grading system.[3] Thus the quality of soybeans affects the processing margin from two directions, through its effect upon the combined value of the products and also upon the pricing of soybeans by processors.

It is not possible to draw a clear picture of the geographical distribution of different levels of soybean oil content in the United States, but there is a general pattern of such distribution. There is a tendency for the oil content to be highest in the central belt and to diminish at both the northern and southern fringes.[4] Since it is not possible to separate the effect of weather and variety on oil content of soybeans these findings represent the combined effect of all the factors contributing to the determination of oil content. It is presumed that these natural factors affecting oil content change very slowly over time, generally as a result of introduction of new varieties. In the long run the oil content of soybeans in different areas may tend to be equalized through introduction of higher oil content varieties where the oil content is low, although there is always the effect of the weather upon oil content.

The above general pattern of the geographical variation of oil content, which is still in line with the current judgment of the trade, would mean that other things being equal the individual mills located

[1] West, V. I., Evaluation of certain systems for differentiating market qualities of soybeans. Unpublished Ph.D. thesis, University of Illinois, 1951.

[2] *Marketing Study of Factors Affecting the Quantity and Value of Products Obtained from Soybeans, op. cit.*

[3] The usual system of pricing soybeans sold by country elevators to processors includes no premiums, but it does discount soybeans below Grade No. 1 quality. As a result, the seller is generally underpaid for soybeans meeting requirements better than called for by Grade No. 1. From the standpoint of processors it is most advantageous to buy soybeans with higher oil content on the basis of Grade No. 1, giving no premium for soybeans that meet better requirements and discounting any lot that falls below Grade No. 1.

[4] Pahigian, Noriar, *Marketing Study of the Oil Content of Soybeans as Related to Production Areas and Climate,* Production and Marketing Administration, USDA, 1950.

in the high oil content areas of soybean production have an economic advantage over mills in other areas as long as they do not pay premiums for the higher oil content.

A fourth factor, which may be mentioned as having had importance, at least historically, in the determination of processing margins of individual mills, is the type of operation, that is, whether screw-press equipment or solvent extraction. Because of the fact that practically all soybean processing plants in the United States employ solvent extraction at the present time we can no longer see any significant individual differences resulting from types of operations. It must be admitted, however, that there are several kinds of solvent extraction equipment which, together with the skill of labor involved, affect yields of oil and meal at different mills.

The actual yields of oil and meal in different areas in the past few years are shown in Table 14. They represent the combined effect of quality of soybeans and processing technology.

Finally it must be pointed out that the quality of the soybean products manufactured affects the prices received for them by individual mills. However, when the processing method is quite uniform as at present, the quality of the products may be assumed to be homogeneous, except for some slight differences that may be attributable to the original quality of the raw material soybeans and the quality control system of individual firms. The effect of quality upon prices of the products received by individual mills cannot be determined.

Thus far we have enumerated all the factors affecting processing margins of individual mills. The two factors, location and management, are of prime importance in the determination of actual processing margins of any mills in the industry. In the main the processing margin is circumscribed by locational conditions and finally determined by decisions of management pertaining to purchases and sales of soybeans and soybean products in both the cash and the futures market.

Processing Margins and Net Returns

For any processing plant in a given location, once the processing margin is fixed for any length of operation by the factors described above, net returns to capital and management depend solely upon the magnitude of the total processing cost at the plant in relation to the given magnitude of the processing margin. The processing margin, as defined, is a gross margin for any individual mill. Thus, if we subtract the total processing cost from the gross margin, we get the

Table 14. — Yields of Oil and Meal per Short Ton of Soybeans Processed, Specified States and U.S. Average, 1959-61 Crop Years

State	1959		1960		1961		1959-61 average		1959-61 average per bushel	
	Oil	Meal	Oil	Meal	Oil	Meal	Oil	Meal	Oil	Meal
					(pounds)					
Illinois	365	1,538	378	1,516	373	1,526	372	1,527	11.16	45.81
Minnesota	349	1,584	354	1,548	358	1,558	354	1,563	10.62	46.89
Indiana	357	1,599	370	1,570	363	1,590	363	1,586	10.89	47.58
Iowa	355	1,614	362	1,596	358	1,604	358	1,605	10.74	48.15
Missouri	368	1,580	([a])	([a])	([a])	([a])	368	1,580	11.04	47.40
Ohio	348	1,614	371	1,568	359	1,602	359	1,595	10.77	47.85
Arkansas	347	1,540	364	1,547	365	1,542	359	1,543	10.77	46.29
Mississippi	371	1,658	369	1,562	382	1,576	374	1,569	11.22	47.07
North Carolina	308	1,573	336	1,558	355	1,574	333	1,568	9.99	47.04
Tennessee	359	1,562	363	1,528	372	1,558	365	1,549	10.95	46.47
Other states	346	1,583	358	1,582	360	1,572	355	1,579	10.65	47.37
U.S. average	359	1,574	367	1,554	365	1,566	364	1,565	10.92	46.95

[a] Included in "other states" to avoid disclosure for individual firms.
Source: *The Soybean Blue Book*, 1961 and 1962.

residual which includes a return on investment and net profit, if any, for the mill. Under the condition of a given magnitude of the processing margin, the lower the cost of processing the higher will be the level of net returns per bushel processed, provided that the residual is positive. It is also possible that the total processing cost is greater than the processing margin, in which case loss is inevitable, the amount of loss depending upon the level of processing cost in relation to the magnitude of the processing margin. In order to maximize net returns, therefore, individual mills must both widen their processing margins and minimize their processing costs.

Importance of operational factors. The total processing cost depends upon the physical or technological factors of the type of extracting equipment and the size of mill. However, certain operational factors, especially rate of plant operation in relation to capacity, and the degree of both horizontal and vertical business integration, significantly affect the profit situation of any individual mill. Equally important is the ability of management to maintain highest possible efficiency under given circumstances.

The rate of operation most directly affects the unit cost of processing. From the cost standpoint it is most desirable to run a mill at its planned or optimum capacity throughout the year. Anything less will result in a higher unit cost because of the spread of fixed charges over smaller volume. (Under the assumption of pure competition, marginal revenue equals marginal cost at the least cost point on the average total cost curve.) Even when a mill is not operating it incurs fixed cost such as depreciation, interest, taxes, insurance, salaries, and administrative expenses. Other things being equal, the closer the level of operation is to that of planned capacity, the lower will be the unit cost of processing in all cases.

Profitability of processing operations by area. In an attempt to estimate net returns, we encounter difficulty not only in estimating the processing margin, but also in estimating the processing cost. In practice it is not possible to estimate net returns for individual mills because of the limitations of data in both quantity and quality.

If we assume, however, that the average total processing cost of plants in each state is about the same, profitability and competitiveness of mills by state can be estimated by respective magnitudes of the processing margin. As an example let us consider the processing margin in Illinois and compare it with the industry average.

The average processing margins for Illinois for the past ten years are shown in Table 15. The computed margins are based on the cash

Table 15. — Average Processing Margins for Illinois Processors, Monthly and Season Average, 1951-60, Cents per Bushel of Soybeans Processed[a]

Crop year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Season average
1951-52	45.7	29.1	17.5	7.1	1.6	−1.9	15.3	27.3	25.2	21.1	37.4	44.7	22.7
1952-53	25.5	16.4	20.9	14.3	9.1	10.5	7.0	5.1	5.4	10.7	9.5	21.8	13.9
1953-54	23.7	6.2	7.9	3.5	1.7	−4.1	0.6	0	−4.4	2.2	13.7	34.6	7.2
1954-55	17.3	43.0	24.8	18.1	14.4	11.3	12.7	13.7	19.3	18.3	12.9	33.8	17.6
1955-56	29.5	17.2	10.9	13.6	11.9	12.7	3.5	−0.6	−5.3	12.3	8.1	16.5	11.1
1956-57	13.9	19.0	26.4	32.7	29.2	17.8	10.3	6.4	6.6	6.4	9.7	25.2	18.2
1957-58	21.8	15.4	8.6	12.3	17.6	27.5	36.8	28.7	22.5	46.1	25.6	40.1	25.3
1958-59	30.1	42.0	39.6	41.1	15.9	14.8	13.7	10.6	13.3	23.7	29.8	23.6	24.6
1959-60	26.6	16.5	15.8	19.3	12.7	6.8	9.8	8.6	13.1	9.2	9.7	20.5	13.8
1960-61	14.4	11.8	15.4	10.6	12.7	6.4	4.1	0.6	4.6	13.7	18.8	28.6	11.7
10-year average	24.9	21.7	18.8	17.3	12.7	10.2	11.4	10.0	10.0	16.4	17.5	28.9	16.6

[a] Calculations done in the same manner as in Table 12. Prices of oil and meal were used on the basis of 11-pound oil and 47-pound meal yields per bushel of soybeans processed.

prices of No. 1 Yellow soybeans at Illinois country shipping points, and Decatur prices of oil and meal, unrestricted billing. The margins thus computed represent more accurately the actual processing situation because the track country station prices were used instead of farm prices of soybeans, although there are certain limitations due to the nature of the data used. The use of the track country station prices of No. 1 Yellow soybeans tends to produce a slight downward bias on the computed margins because of the processor discounts on lower grade soybeans (moisture and dockage) purchased at processing plants. On the other hand, the use of soybean meal prices for unrestricted billing tends to have an upward bias on the margins because meal is sold at lower prices under restricted billing.

Taking into consideration the different soybean prices used for our computation, we may compare the Illinois margins shown in Table 15 with the industry average margins shown in Table 13. The difference is certainly bigger than the elevation charges at country elevators, which may average about 5 cents per bushel in Illinois. The recent ten-year average annual gross margin per bushel of soybeans processed in Illinois is only 17 cents, which in many cases could not have covered the total cost of processing, although it would have been sufficient to cover the variable cost of processing. (Variable cost includes acquisition, current operating, and selling costs.)

It is true that the computed margins in Table 15 do not necessarily represent the actual gross margins for individual processors in Illinois, yet the big difference between the Illinois margins and the industry averages must indicate that the profit situation in Illinois is at a disadvantage compared to that of other areas, and that soybean mills in Illinois sometimes suffer losses in their processing operations until they improve their processing margins by inventory management and whatever other means are available to them.

Locational Analysis of Soybean Processing

Obviously the most favorable locational situation for soybean processing is one in which soybeans are produced in the areas near where meal and oil are consumed. But soybeans are produced in limited areas of the United States, while the products of soybean processing are distributed throughout the country and are also exported to various markets of the world. Under these geographical conditions the activities of processors must be so organized as to take the best advantage of the locational factors affecting their operations if they are to maximize their net returns. In this section we shall examine locational factors, especially the transportation economics of the soybean processing industry, and discuss the relation of these to the competitive situation of individual mills.

Economics of Plant Location

Insofar as transportation costs are concerned, the general principle governing the location of manufacturing industries is that an industry will tend to locate where the transportation charges are the least. Whether the industry will be drawn toward the source of the raw materials or toward the market of the finished products depends upon the relative cost of transporting the raw materials and the finished products. The cost of transporting the raw materials is the product of the freight rate on the raw materials and their weight, while the cost of transporting the finished goods is the product of the freight rate on the goods and their weight. Thus it follows that the relative transportation costs of the raw materials and the finished products are determined by the loss of weight that results from the manufacturing process, and the relation of the freight rate on the raw materials to the freight rate on the finished products.[1]

In case there is a loss of weight in the manufacturing process, an industry may be expected to locate at the source of the raw material, other things being equal. Perishability of raw materials may also confine processing to the source of raw materials in order to minimize deterioration as well as to take advantage of loss of weight in the manufacturing process.

If the rates on the raw materials are higher than on the finished products it will be advantageous to locate a manufacturing plant at the source of the raw materials. On the other hand, if the rates on the finished products are higher than on the raw materials, which is true in most cases, there is an advantage in locating a plant near the market for the products, unless this advantage is offset by loss of weight in the manufacturing process. (Apart from the fundamental principle of transportation, some commodities are tied to the market by their intrinsic nature. For instance, the service industries, daily papers and baked goods, etc. are more or less confined to the area where they are consumed.)

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[1] Locklin, D. P., *Economics of Transportation,* Chapter 4, "Freight Rates and the Location of Industries and Market Centers." Richard D. Irwin, Inc., 5th Edition, 1960.

There are several qualifications to the above-mentioned principle from a practical standpoint.

First, it must be recognized that the importance of transportation varies from industry to industry. If transportation costs are a large item in the total cost of production and constitute a relatively large part of the value of the product, they may be a decisive factor in the location of the industry. But on the other hand, if transportation costs are a small part of the production cost and also constitute a relatively small portion of the delivered price of the product, they may have little influence upon the location of the industry.

Secondly, because railroad freight rates are usually constructed on the tapering principle, transportation costs do not increase in direct proportion to distance. Thus the rate for a distance of 1,000 miles will be less than twice the rate for 500 miles. The effect of the tapering principle is to draw manufacturing activities either to the source of the raw material or to the market, the intermediate points being at a disadvantage.

A third qualification to the fundamental principle of transportation involves transit privileges which are widely used in transportation of many commodities. A transit privilege is defined as "the privilege of stopping a shipment enroute to enable some process or operation to be performed on the article, and of reshipping to final destination at the through rate applicable from the original shipping point to destination."[1] Thus the privilege is of great importance to industries not located at rate-breaking points. The milling-in-transit privilege, which is applicable to grain shipment including soybeans, is probably the most common example of this privilege.

The general effect of the transit privilege is to neutralize the working of the tapering principle between origin and destination by equalizing the sum of the in and out rates at such intermediate points as are granted the privilege, thus facilitating the decentralization of the industry. Under the transit arrangement, factors other than transportation cost may have the most important effect upon location of manufacturing activities.[2]

Processing of soybeans in transit. Processing soybeans in transit has been an accepted practice since the earliest days of the industry in the 1920s. In accordance with the general principle of milling-in-transit, the eligible outbound tonnage in the case of soybean processing

[1] *Economics of Transportation, op. cit.*, p. 579.

[2] For a detailed account of the general aspects of the transit privilege, see Hedlund, E. C., *The Transportation Economics of Soybean Processing*, University of Illinois Press, 1952.

is the inbound tonnage less loss of weight or shrink in the manufacturing process. In contrast to the case of wheat for milling, however, the loss of weight in soybean processing includes not only loss of moisture and dockage or waste in processing operations, but also the weight of oil extracted in the process, although soybean oil itself has the transit privilege when it moves from its point of origin as oil. Thus the outbound tonnage of soybeans processed in transit is about 80 percent of the inbound tonnage, the difference of 20 or 21 percent being due mainly to the weight of oil (18 percent) and loss of moisture. The amount of shrinkage is usually computed by processors and deducted from the inbound freight bills.

Effect of transit on soybean processors. Apart from its effect of equalizing locational advantages of various mills, the transit system tends to reduce the transport costs of a processor by providing additional terminal services at no extra cost or at only a small cost. This reduction in the total costs may well be reflected either in better prices for soybeans or lower prices for products or both. Transit may also facilitate enlargement of plant scale to a more optimum size by providing low cost transportation over wide territories, which in turn may result in higher productive efficiency in the industry to the benefit of both producers and consumers.

From a broader standpoint of general public interest, however, it may still be asked who finally bears the cost of additional services incurred by railroads under transit arrangements. (Additional charges incurred in transit include not only terminal services but also the cost of supervision, record checking, adjustment of complaints on charges, publication of tariffs, etc., that go along with transit.) If the rates under transit are not sufficient to cover the actual cost of transportation, which seems to be the case, the railroads must be making up for the loss by charging higher rates on nontransit commodities and shippers. On the other hand, if the through rates under transit with all the additional services were initially calculated by the carriers to be just and reasonable, and enough to cover the actual cost of transportation, there is no basis for justification of local rates which are higher than the through rates. If such be the case, general levels of freight rates must be lowered.

In either of the above cases, the freight rates under transit are discriminatory and preferential, because the transit rates mean lower rates only for individual cases involved. Considered in this light, there is little economic justification for this discriminatory practice except that the system has long been a part of the grain trade and its sudden discontinuation is practically impossible.

As already pointed out, the soybean processing industry in the United States has developed under the institution of processing-in-transit privileges almost since its birth. Locations of processing plants, pricing systems, and trade practices have all been affected by the transit arrangements. Any major change of this important aspect of transportation would bring about drastic changes in the competitive position of individual mills. Yet over time railroads will make continuous adjustments that will decrease the importance of the transit system in the overall freight rate structure. In the long run, therefore, the effect of the tapering principle as described before may have more influence on the location of processing activities.

Location of soybean processing plants. With the above discussion in mind let us consider the application of economics of plant location for soybean processing.

Since soybeans are not perishable, and the loss of weight and changes of volume in processing are rather limited, these characteristics are not important in the location of processing plants. In the case of soybeans the most important factor influencing location of processing must be the relation of freight rates on soybeans and soybean oil and meal in the general framework of the transit system.

For the purpose of simple illustration we shall select Decatur as the source of the raw material as against the market for both oil and meal in Boston, New York, Baltimore, New Orleans, Los Angeles, and Seattle. The comparison here is to determine whether it costs less in terms of transportation to process soybeans in transit at Decatur and ship products to the market than to ship soybeans under nontransit rates to the market to be processed at a hypothetical plant. To make this hypothetical comparison we assume that the processing cost is the same whether processing operations take place at Decatur or at the market and that there is no further transportation cost involved in the distribution of the products when soybeans are processed at the market. The results of the calculations for 1946 and 1962 are shown in Table 16.

Our calculations indicate that under the conditions that prevailed in 1946 there was very little difference in terms of the transport costs, except for the two locations on the west coast, whether soybeans were processed at Decatur or at the specified markets. With respect to the west coast, the advantage of processing soybeans at Decatur was quite clear due to the relatively low rates applied on the meal and oil. At

Table 16.—Transport Costs in Cents per Bushel of 60 Pounds of Soybeans Under Nontransit, as Compared to the Cost of Transporting Equivalent Quantities of Oil and Meal Under Transit From Decatur, Illinois, to Specified Markets, 1946 and 1962[a]

Market	Bushel of soybeans		Equivalent oil[b]		Equivalent meal[c]		Total products		Favoring nontransit	
	1946	1962	1946	1962	1946	1962	1946	1962	1946	1962
Boston	24.0	50.4	4.77	10.67	19.79	39.72	24.56	50.39	+0.56	−0.01
New York	22.8	49.2	4.59	10.01	18.86	38.78	23.45	48.79	+0.65	−0.41
Baltimore	21.0	47.4	4.23	9.35	17.45	37.37	21.68	46.72	+0.68	−0.68
New Orleans	21.9	31.5	4.77	10.23	18.62	22.09	23.39	32.32	+1.49	+0.82
Los Angeles	45.6	100.2	7.65	15.73	30.37	62.51	38.02	78.24	−7.58	−21.96
Seattle	45.6	100.2	7.65	15.73	30.37	62.51	38.02	78.24	−7.58	−21.96

[a] The rates applied are the lowest possible domestic carload rates to destination as of June 30, 1946 and October 31, 1962. A minimum inbound soybean rate eligible for transit was 6.5 cents per 100 pounds in 1946 and 10 cents in 1962 in most transit arrangements.

[b] Based on 9 pounds of oil yield per bushel for 1946, and 11 pounds of oil yield for 1962.

[c] Based on 48 pounds of meal yield per bushel for 1946, and 47 pounds of meal yield for 1962.

Remarks: For 1946, transport costs were computed on the basis of the rates provided in Table 36 in *The Transportation Economics of the Soybean Processing Industry* by E. C. Hedlund, the University of Illinois Press, 1952. For 1962, transport costs were computed on the basis of the rail rates provided by a grain and feed ingredients merchandising firm in Champaign, Illinois.

New Orleans the advantage of transporting the raw material soybeans and processing them at the market was about 1.5 cents per bushel. In the absence of the transit privilege on meal the advantage of processing soybeans at the selected markets would have been greater than indicated in the table, provided that there was no transportation cost involved in the distribution of the meal and oil manufactured at the market.

In 1962 the fundamental relationships seen in 1946 remained unchanged. The figures indicate that processing soybeans in transit at Decatur and shipping products to the market was slightly more advantageous in 1962 than in 1946. For the west coast markets this advantage has been greatly increased.

In actuality it would be rather difficult for a large processing plant at the market to sell all the oil and meal produced at no transport cost to the mill. When we take into consideration this additional cost of transportation which is most likely to be incurred by the plant at the market, all the positive balances favoring nontransit in 1946 (Table 16) would turn into negative balances, indicating an advantage of processing soybeans in transit at Decatur.

Furthermore, on the side of processing at Decatur we must bear in mind that processors at the source of the raw material need not ship their products to any particular direction or market as does the hypothetical plant at the market with no transport cost. It must also be pointed out that the heavy soybean producing areas are among the largest users of soybean meal, and also consume large quantities of crude oil, especially in Illinois, for manufacturing edible fats and oils products. Therefore, the plant at the source of the raw material soybeans can minimize its transport costs by buying soybeans at the plant and selling the meal for local consumption and shipping the oil to the nearest market. Plants in these producing areas can also utilize the transit system and supply the meal to distant markets at reduced transport costs. Thus, the flexibility of operation of the plant in the area of soybean production, with its access to various markets, both far and near, holds a definite advantage over processing operations at the market.

But it must be admitted from our calculations that as far as only the relative rail rates on soybeans and soybean products are concerned, there seems to be no decisive advantage either on the side of processing at the source of the raw material or on the side of processing at the market (except for the markets on the west coast), provided that there is no drastic change in the rate structure or in the transit system.

So from this standpoint alone it may be argued that if the market for the joint products of soybean processing is large enough to permit the operation of an optimum-size plant it is economically feasible to build to a soybean plant at the consuming centers in the east or the south. But when other relevant factors are taken into consideration soybean processing is oriented toward the source of the raw material, or locations in the heavy soybean producing areas which happen to be close to the center of population and near the geographical center of the United States.

The most important transportation factors affecting the location of soybean processing plants can now be summarized as follows: (1) the existence of the transit system applicable to soybean processing operations with all the individual differences of the carriers involved; (2) the relative rates on soybeans and soybean products, coupled with the non-applicability of the transit privilege to soybean oil produced; and (3) availability of transportation facilities to serve wide-spread markets. Also important, apart from these three factors, are the location of competing mills and pricing practices in the industry. It should be kept in mind that railroad transportation, as well as other modes of transport, namely water and truck, have become increasingly important in recent years.

Some of the other reasons for locating a soybean plant will be tax rates, labor rates, and availability of water and utilities. Animal and poultry population in the areas surrounding a proposed site constitute a very important locational factor as an indication of the potential local market for soybean meal.

Foreign procurement of U.S. soybeans also affects location of processing plants in the United States. For instance, when there were relatively small quantities of soybean exports from the United States up until 1953-54, the producing areas in the mid-south were almost tributary to the Chicago market since there were no soybean processing plants buying soybeans in these areas. Therefore, soybeans had to be sold at a discount of approximately the cost of transportation to Chicago. But since soybean exports have continued to increase rapidly, soybeans in the mid-south began to command a premium over Chicago prices due to their proximity to the export gate of New Orleans. The premium generally cannot be as great as the transport cost from the producing areas of Illinois, Indiana or Missouri, yet at times exporters will pay a premium of 15 to 20 cents per bushel above the Chicago price. These high prices of soybeans in areas adjacent to points of export certainly discourage processing operations near the export gates in the south and the east, because in these places processors must compete for procurement of soybeans with foreign buyers who are willing to pay higher prices to obtain soybeans from the United States.

Transportation by Barge and Truck

In the postwar period, until a few years ago, the railroads repeatedly raised their rates in order to meet their ever-increasing costs. These increases stimulated the rapid expansion of the barge and trucking industries which have maintained relatively low rates. Clearly the result has been an increasing volume of business for barge and truck, while the railroads have suffered from this competition. From 1935 to 1958 the rail share of total grain movements to Chicago declined in varying degrees, depending on the commodity. For instance, rail receipts of corn at Chicago declined from 84 percent to 67 percent of total receipts; oats declined from 94 percent to 69 percent; and soybeans declined from almost 100 percent to 33 percent.[1]

With respect to water transportation of grain, the Illinois waterway complex (Mississippi and Tennessee Rivers) is the most important waterway system in the United States connecting the heart of grain producing areas of the midwest and the important terminal markets of grain for both domestic and export outlets. The importance of this waterway system has increased tremendously in the past 20 years or so. In 1935 all grains moving to Chicago on the Illinois Waterway totaled only 1.5 million bushels. By 1940 this increased to about 20 million bushels, and further to almost 65 million bushels by 1958. The movements of grain on the Tennessee River have increased greatly in the past few years after the river was developed into a nine-foot navigable channel for most modern barges. In 1940 the amount of grain moved by barge on the Tennessee River was less than 50,000 tons; in 1950 it was only 160,000 tons. By 1958, however, it increased to one and three-quarter million tons.[2]

For the soybean processing industry, the opening of the Tennessee River for modern barge transportation has had an important effect.

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[1] Agricultural Industries Forum, *Grain Marketing Proceedings* of the Second Forum, February 2-3, 1960, pp. 23-28. Cf. "Coordinating Rail, Truck and Water Grain Rates," by Richard M. Freeman of Belnap, Spencer, Hardy and Freeman, Chicago, Illinois. For grain movements in recent years in the north-central region by different modes of transport, see Storey, D. A., *Truck Shipments of Grain by Country Elevators in the North-Central Region,* 1954 to 1958-59, Ill. Agr. Exp. Sta. AE-3674. This study indicates an increasing percentage of truck shipments of all grains by country elevators in the region during the period covered.

[2] For reference, see Agricultural Industries Forum, *Proceedings for 1960,* pp. 23-28.

Grain can be transported by barge at low cost from central and northern Illinois and the upper Mississippi River. The grain can be unloaded and trucked to Georgia, Alabama, Mississippi, and farther to the Carolinas and Florida. The low cost of this barge-truck transportation of grain has promoted the rapid development of livestock breeding in the southeastern states. The growing poultry and livestock industry in these areas has created an excellent market for soybean meal to be used in the manufacturing of mixed feeds. Favorable conditions for processing soybeans have thus been created in the southeastern part of the United States.

The principle that soybean processing in transit is oriented to the source of the raw material in the north-central region of the United States is no longer tenable in the face of the low cost transportation of soybeans by barge, coupled with the low cost delivery of meal by truck. Furthermore, soybean oil produced in the southeast can either be transported to the metropolitan areas in the east by rail or by tank truck or in some cases like Norfolk, Virginia, by intercoastal barge, or exported from the seaports to overseas markets.

Because of the advantage afforded by barge and truck transportation, several new soybean processing plants have been built in the south and the southeast in the last few years where only a few small solvent plants existed in the early 1950s. Most of these new big plants are at locations on or near the Mississippi and Tennessee Rivers or their navigable tributaries, where all modes of transportation are available. Notable examples are plants at Guntersville, Alabama, and another at Chattanooga, Tennessee. Mills were also built to utilize the local production of soybeans for the consumption of soybean meal in the southeast. These new plants are located at Raleigh and Salem in North Carolina, Estill in South Carolina, and at Norfolk, Virginia.

Competition among railroads, barge, and truck. Railroads compete with other modes of transportation as well as among themselves for moving grain and grain products. In competition for grain traffic, barges and trucks generally have the advantage of flexible rates over railroads. Under the Interstate Commerce Act the transportation of commodities in bulk by barge is exempt from the provisions of the act, and barge lines can change rates on grain in bulk as they see fit to meet competition by other modes of transportation. Trucks also transport grain under the provisions of the agricultural exemptions and can vary their rates without the sanction of the Commission. Rail rates, on the other hand, are subject to various state and interstate regulations, and rate changes cannot be effected as easily or quickly as in the case either of barge or of truck.

In order to cope with the low rates of barge and truck the railroads have made a serious effort to lower their rates in the past few years. In most parts of the country rates on grain and soybean meal have been drastically reduced in an effort to compete with barge and truck. Because of this counter-action by the railroads the advantage of barge and truck transportation is being lost to some extent. Rates on soybean meal and grain have been drastically reduced in most parts of the country, except in the east, and railroads have been able to recapture much of this business. In many cases it has meant cutting their "normal" rates in half. Strangely enough, after the new scales have been introduced, we find that in most instances we get back to about the X-168 level of rates which were in effect in 1949.[1]

Yet from the cost standpoint the fact remains that where waterways are available, grain can be moved at less cost by barge for long distances than by rail, and for short distances truck is the most economical means of transportation.[2]

The competition among the different modes of transportation results in an economic gain for society by benefiting both producers of grain and consumers of grain products. It is true that these changes in transportation patterns are painful to some processors, yet continuous adjustments under competitive conditions are the rule rather than the exception in economic progress.

Effects of Pricing Systems in the Industry

Pricing of soybean products. The effects of transportation costs and other locational factors on the location of plants may be greatly modified by general pricing practices in the industry. The most notable of these industry pricing policies, and one which has had important effect upon the development of the soybean processing industry, is the single-basing-point pricing system. Under this system the price at any place in the country is the basing-point price plus freight for the distance involved.

It so happened that a corn processor at Decatur, Illinois, started soybean processing on a commercial scale in the early 1920s and pioneered the industry, together with several other firms established later in and around Decatur. By virtue of this early start and pioneering work, coupled with favorable conditions of increasing soybean

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[1] Agricultural Industries Forum, *Proceedings for 1960, op. cit.,* p. 21.

[2] In this comparison, the question of public investment and maintenance of waterways and highways is disregarded. Cf. *Economics of Transportation, op. cit.,* Chapter 30, pp. 646-647, and Chapter 33, pp. 715-721.

production and availability of market outlets for soybean products in Illinois and surrounding areas, Decatur became the center of soybean processing activities in the country. It became a standard practice to quote prices of soybean products at f.o.b. Decatur, Illinois. More firms entered soybean processing in surrounding areas, and they made their quotations on the basis of the Decatur price plus freight from Decatur to location of their customers, thus establishing in effect the basing-point pricing system in the soybean processing industry.[1]

At first the basing-point pricing system was acceptable and also beneficial to both processors in and near Decatur. The Decatur processors were not undersold anywhere in the country, while processors in other areas could obtain a higher factory price than the Decatur prices in markets that were closer to them than to Decatur. Processors in other areas, however, were not able to sell in markets which were nearer to Decatur than to their own locations, unless they absorbed the differences in freight. From the standpoint of customers, the pricing system meant that they always had to pay the freight rates from Decatur whether they made their purchases from the Decatur processors or from local plants.

Thus it is apparent that under the basing-point pricing system the market area of the Decatur and other Illinois processors covered the whole country, while the nonbasing-point processors had a more restricted market area. This tended to encourage expansion of processing operations at Decatur and other Illinois points in the early period, which in turn retarded expansion in other areas.

As long as the basing-point system was in effect in the industry, the most advantageous location for a processing plant was at the farthest possible point from Decatur where local soybeans were available and where meal produced could be locally sold at a price based on the Decatur quotations plus freight. This allowed the processor to retain the freight advantage as revenue. So plants were built in areas surrounding Illinois, notably in Iowa, Indiana, and Ohio quite early and then in Minnesota and other outer areas in the west and the south of Illinois as soybean production expanded into these areas. Plants in the surrounding areas increased in number and became more aggressive in the postwar years to secure wider market areas. In consequence the Decatur and other Illinois processors were hard pressed by this competition.

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[1] The decision of the Supreme Court of the United States in 1948 in Federal Trade Commission v. The Cement Institute, 333 U.S. 683, outlawed the basing-point pricing system insofar as it involves collusion or concerted action among producers.

To cope with this situation the Decatur processors started quoting several different prices for different geographical areas depending upon the degree of competition. In effect the increasing competition forced them to absorb a part of the freight rates. As a result of this counteraction by the Decatur processors, the processors in areas outside central Illinois had to face a freight penalty to certain destinations and their overall freight advantage was reduced. The meal produced and sold by these processors in areas where they had a freight advantage or penalty came to be known as "restricted meal," while the meal produced in and around Decatur was regarded as "unrestricted meal" because of its access to an unrestricted choice of destination. Yet fundamentally it remains that prices of soybean products, especially meal, at Decatur are the basis for prices in other areas which are generally higher than the Decatur quotations, although price differences between Decatur and other markets have tended to become narrower over the years. This is due partly to increased competition, increased soybean production, and partly to reduced freight rates on meal in the past few years (Table 17).

Another important aspect of the single-basing-point pricing system is its effect upon location of industries which depend for their raw materials upon the products of the industry maintaining the single-basing-point system. Because the prices of the products under this pricing system are lowest at the basing point and higher at all other places, including other producing points, industries using the products as their basic raw materials would tend to locate near the basing point. In the case of soybean products, feed manufacturers and vegetable oil refineries and related food fats and oils industries found their locational advantage at Illinois points and actually built their plants in Illinois, providing excellent markets for products of soybean processing.[1] The mutual interdependence and transportation advantage between the processors and the users of soybean meal and oil, together with heavy production of soybeans, strengthened the position of Illinois as the center of soybean processing in the United States.

Today soybeans produced in Illinois typically have multiple destinations because of the state's geographical position in relation to the Chicago, Peoria, St. Louis, and many other markets within as well as outside the state. These markets are for both domestic crushing and

[1] According to a special study by the USDA, during the 1956-57 season, over 30 percent of refined soybean oil production was concentrated in Illinois, with an additional 35 percent processed by refineries located in eight eastern states. *Capacity and Processing Trends in the Fats and Oils Industry, op. cit.*, p. 30.

Table 17.—Average Wholesale Price of Soybean Meal at Specified Markets, Dollars per Short Ton, Bulk, 1956-60

Crop year	Decatur	San Francisco	Denver	Fort Worth	Kansas City	Minneapolis	Memphis	Chicago	Cincinnati	Atlanta	Baltimore	New York	Boston
1956-57	47.45	72.50	65.80	62.95	54.60	53.80	50.05	53.35	55.05	59.65	61.50	63.30	62.05
Price over Decatur	0	25.05	18.35	15.50	7.15	6.35	2.60	6.90	7.60	12.20	14.05	15.85	14.60
1957-58	53.40	79.00	69.80	68.80	60.60	59.30	56.00	60.40	61.60	65.15	67.65	69.30	68.40
Price over Decatur	0	25.60	16.40	15.40	7.20	5.90	2.60	7.00	8.20	11.75	14.25	15.90	15.00
1958-59	55.80	79.05	69.00	68.30	61.50	61.05	59.60	60.50	63.60	66.00	69.90	71.00	70.35
Price over Decatur	0	23.25	13.20	12.50	5.70	5.25	3.80	4.70	7.80	10.20	14.10	15.20	14.55
1959-60	55.55	76.60	67.30	64.05	58.20	58.65	58.05	60.05	63.00	63.80	68.45	70.15	68.85
Price over Decatur	0	21.05	11.75	8.50	2.65	3.10	2.50	4.50	7.45	8.25	12.90	14.60	13.30
1960-61	60.60	82.75	72.15	68.90	64.20	65.60	62.25	64.30	67.45	68.30	73.35	75.55	73.65
Price over Decatur	0	22.15	11.55	8.30	3.60	4.90	1.65	3.70	6.85	7.70	12.75	14.95	13.05
1956-60 average	54.56	77.98	68.81	66.60	59.82	59.66	57.19	59.92	62.14	64.58	68.17	69.85	68.66
Price over Decatur	0	23.45	14.25	12.04	5.26	5.10	2.63	5.36	7.58	10.02	13.61	15.29	14.10

Source: *Feed Market News*, Grain Division, AMS, USDA, Volume 44, No. 40, pp. 4-6.

Table 18. — Farm Prices of Soybeans in Specified States, 1956-60 Crop Years, Dollars per Bushel[a]

State	1956	1957	1958	1959	1960	1956-60 average
Illinois	2.27	2.14	2.07	2.03	2.47	2.20
Minnesota	2.14	1.99	1.97	1.91	2.39	2.08
Indiana	2.24	2.11	2.01	2.01	2.43	2.16
Iowa	2.20	2.03	1.97	1.93	2.42	2.11
Missouri	2.24	2.08	2.01	1.98	2.41	2.14
Ohio	2.23	2.13	2.02	2.03	2.45	2.17
Arkansas	2.26	2.13	2.02	2.02	2.43	2.17
Mississippi	2.22	2.09	2.06	2.01	2.36	2.15

[a] Simple averages of mid-month prices.
Source: *Agricultural Prices,* Statistical Reporting Service, Crop Reporting Board, USDA.

export. As a result, soybean prices in Illinois are generally highest in the nation and the Illinois processors must pay higher prices on the average than processors in other states to get their soybeans. In this sense the freight advantage for soybean purchases still remains for processors in other areas, although this advantage is different in nature from the case of a single delivery point as explained before (Table 18).

Competitive Position of Processing Plants by Area

Empirically the aggregate of all locational influences as discussed above can be measured in terms of processing margins and actual transportation costs of soybeans and soybean products. These margins can be computed from available data on an individual state basis. The computed margins have limitations in their meaning, yet they may be taken as approximating the overall profitableness and competitiveness of processing operations in different areas.[1] Within this framework of the basic margin situation we can further investigate, in terms of transportation costs, the competitive position of processors in reaching the market for their products.

Taking into consideration the various factors of yields of oil and meal and prices of soybeans and products at different locations, we have computed the processing margins for different states. The results are shown in Table 19. The computed margins are based on farm prices of soybeans and are therefore bigger than the actual

[1] These margins merely indicate the average possible magnitudes of processing margins in different areas under specified conditions of computation. In this sense they represent an average opportunity for processors in their respective areas. The actual margins for individual mills may be smaller or larger, depending upon their specific locations and skill of management in purchase of soybeans and sale of soybean products.

Table 19. — Soybean Processing Margins in Specified States, 1956-60, Cents per Bushel of Soybeans Processed[a]

State	1956-57	1957-58	1958-59	1959-60	1960-61	1956-60 average
Illinois	23.4	28.8	26.8	16.9	17.9	22.8
Minnesota	27.0	53.7	47.0	34.7	34.6	43.4
Indiana	34.3	40.8	42.3	28.7	31.4	35.5
Iowa	35.4	47.6	49.4	35.9	31.3	39.9
Missouri	45.6	54.9	49.6	31.6	35.9	43.5
Ohio	45.5	50.7	52.5	37.1	38.1	44.6
Arkansas	26.6	32.9	38.3	21.7	22.8	28.5
Mississippi	38.3	44.0	40.9	28.7	37.3	37.8

[a] The computed margins include cost of moving soybeans through country elevators to processing plants.

margins for processors at least by the magnitude of elevation charges at country shipping points, although probably the elevation charges would not affect the order of magnitudes of computed processing margins for the different states. (Our main concern here is an ordinal comparison of processing margins in different areas, but modifications of the margins shown in Table 19 will be made later in terms of inbound transportation costs of soybeans.) Of course, it is possible that in actuality there exists a considerable variation in the elevation charges to an extent that may affect our computed margins. But little is known on this point.

Table 19 indicates that Illinois has consistently had the lowest processing margin of the eight states shown in the table in the 1956-60 period, and that Ohio, Missouri and Minnesota have had larger processing margins than Iowa, Mississippi, Indiana, and Arkansas.

Assuming that the average processing cost in each of the states is approximately the same, we may tentatively conclude from Table 19 that processors in Ohio, Missouri, and Minnesota are in the most favorable position in the soybean processing industry. The processors in these states should be able to compete most effectively with processors of other states, such as Illinois, Indiana and Iowa, provided that soybeans and product markets continue to be available in these states.

Before we proceed further in this line of discussion it must be pointed out that the above comparison has important limitations because of the way in which the gross margins were computed. Above all, it was assumed that the meal produced in each state was sold at one price within the state. This is not a realistic assumption, since meal is actually shipped to various markets both inside and outside the state in which it is manufactured. (Oil revenue per bushel of soybeans is taken to be approximately the same in each state.) On the side of the raw material acquisition, it was similarly assumed that soybeans in each state were purchased at one price, and that is another unrealistic assumption.

In view of these assumptions, the preceding comparison is valid only when at least the bulk of the meal produced from the local supply of soybeans is sold within the state in which it is produced. In general, soybeans are acquired from nearby territories and most of the meal produced in each state is sold within the state; so in this sense it can be said that the above comparison is valid as an approximation of the processing situation in different areas. This leads us to investigate the competitive positions of processors in reaching various markets throughout the country. In order to evaluate realistically the overall comparative position of processors in different areas, we must consider the effect of both processing margins and transport costs. In the latter case we must keep in mind the complex institution of the transit system which influences not only shipments from processing plants but also the soybean meal purchasing policies of feed plants. The interactions of all the transit influences result in the actual freight rates paid on soybean meal to various destinations (Table 20).

Table 20 indicates, in terms of transport costs of meal, the competitive position of processors in different states with respect to market areas. Although we are not including in our analysis barge and truck rates on soybean meal, the comparison of railroad rates will give us a sufficiently accurate picture of state-to-state flow of soybean meal in view of the overall importance of rail transportation of this commodity in the United States. It can be noted from the table that meal production in each state is generally sold at the lowest or most competitive transport cost within the state in which it is manufactured. This is only natural in view of the shorter intra-state distance involved except at borderline locations.

Our interest now is in finding the competitive ability of each soybean processing state to reach out-of-state markets after filling its local need. The table shows that in 1960 Illinois shipped to most parts of the country, in many cases at the lower f.o.b. mill prices, to compete with meal from other origins. In terms of transport cost in reaching out-of-state markets, Illinois looks contained by surrounding states, although for many markets Illinois' freight disadvantages are not necessarily great. In principle, Illinois can sell to other markets only by absorbing a part of the transport cost.

Table 20. — Average Freight Rates Paid on Soybean Meal in State-to-State Movement by Class I Railroads in 1960, Dollars per Short Ton, Bulk Carload

Destination	Origin												
	Ill.	Iowa	Ohio	Tenn.	Ind.	Minn.	Mo.	Miss.	Ark.	Kan.	Ky.	N. C.	S. C.
Washington	22.80	20.20				19.20	*16.80*						
Oregon	*15.40*	16.20				20.80							
California	23.00	19.00				21.20	16.60			*15.80*			
Idaho						19.00	*14.80*			16.80			
Colorado		9.80					*6.80*						
Texas	5.40	14.60		4.40			7.40	8.40	5.00	*.60*			
Oklahoma							*2.20*		5.00	3.80			
Kansas	1.00	1.20					*.80*		3.40	3.60			
Nebraska		2.00					*1.40*						
Minnesota		2.00				*1.80*							
Iowa	2.20	*2.00*				3.20							
Missouri	2.20	*1.40*					1.80						
Arkansas	*1.20*			4.20			3.20		3.20				
Louisiana	6.20			3.40			5.00	*3.20*	3.60		1.60[a]		
Wisconsin	3.00	3.00				*2.40*							
Illinois	*1.80*	3.00											
Michigan	4.40		*2.20*		4.20	9.00							
Indiana	5.00				*3.00*								
Kentucky	4.40			5.40							*3.20*		
Tennessee	3.40			3.20	5.80			2.40			*1.60*		
Mississippi	4.80			4.40			5.20	*2.80*					
Alabama	5.00			3.60				5.00			*3.00*		
Georgia	5.60			4.00				6.40			*3.80*		
Ohio	5.00		*2.80*		5.00								
Florida				7.00				10.20			2.40[a]		*4.60*
S. Carolina	6.80			5.00									*3.60*
N. Carolina	7.60		7.20		4.80						5.40	*2.20*	3.40
Virginia	10.80		6.40	11.00	8.80						8.40	*3.60*	4.60
Maryland			*6.40*		4.20[a]								
Pennsylvania	10.80		*5.40*		8.20						7.60		
New York	8.80		*4.40*		6.40								
Connecticut			6.60										
Massachusetts	10.00		*7.00*		7.20								
New Hampshire			*5.60*		13.00								
Vermont			*7.80*		8.60								
Maine			*5.80*		8.60								
New Jersey	10.60		*6.40*		8.60						6.60		
Delaware	11.80		*5.40*		8.60						9.20	6.80	
Weight average	4.42		5.35	4.04	5.90	9.31	4.63	4.68	4.46	6.95	4.16	2.80	4.11

[a] Presumed to be export rates or predominately affected by export rates.

Source: Compiled from *Carload Waybill Statistics*, 1960, Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Statement SS-2, pp. 55-57.

Note: The rates italicized are the lowest average domestic rates paid to destination.

It can be further noted from Table 20 that as far as rail transport cost of meal is concerned, processors in Iowa, Tennessee, Indiana and Minnesota are generally limited to their immediate territories. Minnesota and Iowa ship their meal to the west coast and Indiana ships to the east. But in these shipments processors are at a disadvantage when compared with processing plants that have better locations to serve these markets. Ohio, because of its eastern location, enjoys the best transport cost advantage to practically all eastern and northeastern markets; Missouri has a good transport advantage in most parts of the western half of the United States.

The implications of the above transport cost situation are that in the states which have little transport cost advantage in reaching the outside markets, processing operations would tend to be limited by the size of local demand for meal. Except for a few states, such as Illinois and Indiana, which have been doing out-of-state shipping extensively in the past, and Ohio and Missouri, most other states seem to face this limitation due to their geographical locations.

Soybean oil carries its own transit privilege as a commodity but cannot be shipped out from processing plants under the transit rate, although purchases of oil by refineries and food fats and oils plants are affected by transit considerations on their part. The only way for processors to minimize the transport cost of oil is to sell oil in the local market or ship it to overseas markets under export rates. The actual freight rates paid on soybean oil in interstate movements are shown in Table 21. In the *Carload Waybill Statistics,* from which our table was compiled, no distinction is made between domestic and export shipments, and therefore, some of the rates in the table represent export rates or combined averages of domestic and export rates. As a result some rates look way out of the general pattern of freight structure.

We can observe from the table that (1) no one state has a clear transport cost advantage in reaching markets outside its own territory, and this may be due to the nonapplicability of transit rates on oil; (2) in general the southern states have lower average transport cost, and this may be due mainly to the smaller processing capacity in the south with a higher rate of local sale; and (3) the northern states of Iowa and Minnesota have a transport cost disadvantage as compared with Illinois in serving the same markets, and this is due to their geographical locations.

The inbound freight cost on soybeans affects the ability of processors to expand the market area. In our computation of processing mar-

Table 21. — Average Freight Rates Paid on Soybean Oil in State-to-State Movement by Class I Railroads in 1960, Dollars per Short Ton, Bulk Carload

Destination	Origin											
	Ill.	Iowa	Ohio	Tenn.	Ind.	Minn.	Mo.	Miss.	Ark.	Ky.	N. C.	Ga.
California	18.20	28.40		*13.00*		28.20	17.00					
Colorado	18.60											
Texas	22.20	17.80		*.60*			13.40	13.20	9.00			
Oklahoma		14.40										
Minnesota						6.60						
Iowa	10.80	*10.00*										
Missouri	3.80	11.80				6.20	*.20*					
Louisiana	9.40	16.60		.60[a]		14.20		*8.00*				
Illinois	*4.40*	10.00			6.00	13.00						
Michigan	7.80		*5.00*			20.40				1.60[a]		
Indiana	5.40											
Kentucky	8.20				8.40					*7.20*		
Tennessee	12.00	15.80		6.60		21.80	11.00	4.80	*4.40*	12.00		
Alabama	9.40	22.20		5.20		13.80						
Georgia	13.20		8.00	9.20							11.60	*3.80*
Ohio	*8.20*	12.80			8.40		5.20					
Florida	10.00			*9.40*		18.00					10.20	
S. Carolina	16.20		8.80	12.40						8.80		*6.00*
N. Carolina				13.20								
Virginia			7.80									*7.20*
Maryland	14.20		*7.40*							*7.40*		
Pennsylvania	13.80	21.20	*13.00*		9.20[a]	24.20	10.60[a]					
New York	16.40		*14.80*			22.40						
Connecticut	19.40											
Massachusetts	15.00											
New Jersey	15.60		14.20		16.00					9.00[a]	*14.00*	
Weight average	10.31	17.10	12.38	7.89	14.87	15.60	10.72	7.28	6.24	7.27	13.11	5.10

[a] Presumed to be export rates or predominately affected by export rates.

Source: Compiled from *Carload Waybill Statistics*, 1960, Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Statement SS-6, pp. 44-45.

Note: The rates italicized are the lowest average domestic rates paid to destination.

gins so far we have simply assumed one farm price in each state, although we have noted the necessary adjustment for charges of elevation at country shipping points. Now we may approximate from the data of the *Carload Waybill Statistics* the average rail freight rates paid on soybeans in major soybean processing states (Table 22). The averages of the rail rates alone are certainly higher than the actual inbound freight cost at processing plants due to the fact that in recent years an increasing proportion, probably 30 percent or more, of the soybean receipts at mills are by truck, at much lower cost than by rail.[1] Yet the average inbound transport costs per bushel shown in Table 21 would indicate relative transport cost differences for different processing states.

It can be noted from Table 22 that among the major soybean processing states Indiana, Ohio, and Missouri have slightly higher inbound costs than Illinois, Minnesota, Iowa, and Tennessee. These higher inbound costs would have an adverse effect upon the processing margin. If we assume that the relative inbound transport cost difference of each state as compared with the Illinois basis of 10.3 cents per bushel is directly reflected in the cost of soybeans to processors in the respective states, the five-year average margins shown in Table 19 may be modified as follows:

State	Inbound freight difference compared with Illinois	Revised processing margins, 1956-60 average
Illinois	0	22.8
Minnesota	−0.1	43.5
Indiana	+4.5	31.0
Iowa	−0.4	40.3
Missouri	+2.1	41.4
Ohio	+3.4	41.2
Arkansas	+2.8	25.7
Mississippi	−3.7	41.5

This shows that in terms of the revised margins reflecting the relative inbound freight difference, Minnesota enjoys the most favorable margin, closely followed by Mississippi, Missouri, and Ohio. Next come Iowa, Indiana and Arkansas. Illinois is at the bottom of the list.

In order to evaluate the overall competitive positions of processors we must take into consideration the effect not only of the inbound

[1] Cf. *Truck Shipments of Grain by Country Elevator in the North Central Region, 1954 to 1958-59, op. cit.;* also Storey, D. A., *Truck Shipment of Grain in Illinois, 1954 to 1958-59,* Ill. Agr. Exp. Sta. AERR-30, p. 7.

Table 22. — Average Freight Rates Paid on Soybeans in State-to-State Movement by Class I Railroads in 1960, Dollars per Short Ton, Bulk Carload

Destination	Origin											
	Ill.	Minn.	Ind.	Iowa	Mo.	Ohio	Ark.	Miss.	Tenn.	Ky.	Kan.	N. C.
Illinois	*2.80*		5.20		4.00	5.40			4.20	5.00		
Minnesota		*3.40*		6.80								
Indiana	3.60		*4.80*			6.40				5.00		
Iowa	6.40	4.80	9.20	*3.20*	4.60	13.60						
Missouri	4.80			6.20	*3.60*				2.80		*3.20*	
Ohio						*4.40*						
Arkansas							3.40		*2.40*			
Mississippi								2.20	2.60			
Kansas					4.80		9.00				4.00	
Nebraska					5.20							
Wisconsin	3.40											
Oklahoma							*3.00*					
Tennessee									2.60			
N. Carolina												*1.60*
S. Carolina												3.80
Weight average	3.44	3.41	4.94	3.29	4.13	4.56	4.38	2.20	2.64	5.00	3.84	2.33
Cents per bushel	10.3	10.2	14.8	9.9	12.4	13.7	13.1	6.6	7.9	15.0	11.5	7.0

Source: Compiled from *Carload Waybill Statistics*, 1960, Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Statement SS-2, pp. 53-55.
Note: The rates italicized are the lowest average domestic rates paid to destination.

freight cost but also of the outbound transport cost situation on the processing margins. Our analysis suggests that Missouri and Ohio have best locational advantages, followed by Minnesota and Mississippi. It is interesting to note that Missouri and Ohio have the combined benefit of widest margins and good transport cost advantages in reaching outside markets. Although Minnesota and Mississippi have better processing margins than the other states, their outbound transport cost situation would deteriorate their processing margins rapidly as they compete in markets outside their own local territories. The favorable processing situation in these two states seems to rest to a greater extent than in other areas upon the local demand for soybean products. Consequently, so long as there exists a strong and expanding local demand for soybean products, Minnesota and Mississippi can enjoy better processing margins than most other areas.

Mississippi, Tennessee and Arkansas are advantageously located to reach Gulf ports. Ohio has a definite transport cost advantage in exporting through the Great Lakes and St. Lawrence Seaway, and is quite competitive also in reaching the eastern ports. The southeastern states of Virginia and the Carolinas are in a good position to ship to the European markets. If the world demand for American soybean products increases substantially in the future the processing operations in these states will get a good stimulus for further expansion.

The foregoing analysis has been in terms of comparative processing advantages among different states. Within each of the processing states soybean mills at different locations operate under different locational conditions in much the same way as described above. Some plants may have price advantages in purchasing soybeans or selling soybean products compared with others in the same state. Transport conditions are also different for different locations within the state. For instance, in Iowa, the northwestern corner of the state may be the best location because soybeans are available at lower prices and good meal markets are present in the surrounding areas. In addition, the oil can be sold to the west coast at favorable prices from this location.

With respect to individual plants at given locations, processors generally indicate that the potential for future expansion of their processing operations depends upon (1) local soybean production and (2) local livestock population. A heavy local soybean production is a major advantage to a processing plant in terms of both price and transport cost of soybeans, while local livestock population determines local demand for soybean meal, and as such affects meal revenue at a plant in terms of both price and transport cost. Oil can be shipped to any markets in the country without materially affecting the gross margin.

Causes and Effects of Business Integration in the Industry

Thus far our study has been concerned with operations of individual mills as processing units in terms of cost and locational analysis. We shall now examine the organization of the firm in the soybean processing industry with a view to clarifying the nature and extent of integrated operations.

Types of Integration

Many of the existing soybean processors have long been integrated either vertically or horizontally or both. Vertical integration is defined as a combination of the successive stages of processing and marketing of a basic material. Horizontal integration is defined as a combination of the ownership of two or more plants or firms performing similar functions at the same level in the marketing sequence. Quite often integration was initiated by feed manufacturing firms who built their own soybean processing plants to supply soybean meal for feed. Conversely soybean processors have entered the mixed feed business. This integration in the direction of meal has been very common and prevalent in the industry, and the percentage of the integrated operations of the total number of soybean processing plants has increased greatly (Table 23).

When demand for soybean oil was quite strong during and immediately after World War II, edible fats and oils firms started processing soybeans to secure a supply of oil for their edible products; the reverse direction was quite rare.

The above-mentioned types are the common cases of vertical integration involving the joint products of soybean processing. In addition, there have been cases where grain milling firms or grain handling firms have combined feed mixing and soybean processing. In some instances processors have integrated backward toward the producer of soybeans and operate their own country elevators or stock points, although these are not too common as yet and are generally related to the grain handling business of integrated processors. There are also examples of forward integration toward soybean processing by country elevators, as in the case of cooperative processing plants owned by the cooperative elevators.

Horizontally, expanding soybean processors have developed as multiplant organizations by building new plants or acquiring existing plants at scattered locations. Some of the processors are engaged extensively

Table 23. — Integrated Operations at Soybean Processing Plants, 1950 and 1960

State	Total number of plants processing soybeans[a]		Plants combining feed operations[b]		Plants combining oil refining[c]		Plants combining both feed and oil operations	
	1950	1960	1950	1960	1950	1960	1950	1960
Arkansas	12	1	3	4				
Illinois	32	20	9	12	1	4	1	3
Indiana	10	5	4	3				
Iowa	33	22	15	14	3	3	0	1
Kansas	6	3	6	3				
Kentucky	4	3	0	2				
Louisiana	4	1	1	1				
Minnesota	9	8	5	4	1	2	1	2
Missouri	10	4	4	4	1			
Nebraska	3	3	3	2				
N. Carolina	14	7	1	3				
Ohio	15	8	6	4	1	2	0	1
Oklahoma	8	3	7	3				
Tennessee	7	8	0	3	1			
Others	83	42	13	10	4	3	0	2
Total	250	148	77	72	11	13	2	9

[a] Includes plants which processed soybeans exclusively and those which processed soybeans as well as other oilseeds.
[b] Not limited to mixed feeds but includes manufacture of soybean meal pellets.
[c] Does not necessarily include all the processes of refining.
Source: Based on the directory of U. S. soybean processors provided in *The Soybean Blue Book* of the American Soybean Association, 1951 and 1961 editions.

in grain handling or grain milling as well as soybean processing. In the marginal areas of soybean production in the south and the north, many of the processing firms combine soybean operations with crushing of cottonseed and linseed, respectively. Some large integrated firms operate on all of these oilseeds in their multiplant organizations. Strictly speaking, combination of these business activities by a firm is not in itself a form of horizontal integration, but it is diversification of business activities. However, it can also be regarded as a form of partial horizontal integration in materials or processes or markets.

Causes of Integration

Whatever the causes may be, fundamentally both vertical and horizontal integration is promoted by a firm in an attempt to expand its business activities and improve its net returns. Of the various types of integration mentioned above, our concern is mainly with those related to soybean processing itself and related to the utilization of oil and meal by processing firms.

Vertical integration in meal. The advantages of integrated operations of soybean processing and feed mixing in terms of transport cost of meal were already noted in our cost analysis. From the standpoint of a soybean processor this combination of manufacturing activities seems to be a logical one for a number of reasons in addition to the transport cost consideration. Feed mixing is a comparatively simple operation, even though many different types of feed are compounded in the same plant. Whether he has integrated operations or not a processor prepares his meal in such a way as to enhance its feeding value as an ingredient of mixed feed because it is practically the only outlet for his meal. Thus he knows the quality of his meal and how best to prepare it for feeding efficiency. From here it is simply a short step forward for him to go into feed mixing operations himself. Cost of equipment would not be particularly large compared to that of his solvent plant.

From the standpoint of location, a soybean processor is generally located in farming communities and he can easily find customers for his mixed feed. In fact, the percentage of his local sale of mixed feed could well be greater than that of his local sale of meal under nonintegrated operations.

From the standpoint of marketing, a soybean processor is usually somewhat familiar with the feed market and its behavior. This may even give some flexibility in his marketing activities to choose the best possible outlets in both meal and mixed feed markets.

In terms of economies of scale, a processing plant which is not optimum in size when considered by itself may prove to be quite economical as a source of soybean meal for feed mixing and perhaps as a means of controlling quality or utilizing idle resources.

In sum, combination of soybean processing with feed mixing is a logical means of expanding a processing firm. Its economic advantages accrue not only from the transport cost of meal but also from the elimination of the selling and buying functions between soybean processors and feed mixers. These advantages apply to both large and small processing operations insofar as the meal disposition is concerned. The advantages will be greatest when integrated operations take place at the same plant, but in the framework of multiplant organizations, operations can be more flexible depending upon the individual circumstances involved.

Admittedly feed mixing is a very competitive business, yet in supplying the growing market for mixed feed, integrated soybean processors have the advantage over nonintegrated feed mixers, other things being equal, of at least having their own meal supply. In the case of multiplant operations a processor can utilize his own meal or meal produced by others to his best interest depending upon the prevailing circumstances. Of course the crucial problem for soybean processing firms would be that of selling organizations for their newly manufactured mixed feed. This consideration on the part of processors often leads to the acquisition of feed mixing operations when such integrations are economically and financially feasible. Feed mixing firms, too, recognize the advantages of integrated operations and see that it is in their own interest to expand their business activities and improve their profit situation.

Feed mixing operations depend increasingly upon soybean meal and it is quite natural for feed mixing firms to want to have an adequate supply of meal and to reduce their acquisition costs as much as possible. This tends to promote integration backward to soybean processing, giving firms the advantage of established marketing routes for their feeds, even though they face a new problem of selling oil in integrated operations.

However, this backward integration of feed mixing with soybean processing is not as easy and simple as the forward integration of soybean processing with feed mixing. This is true because the solvent extraction process is a relatively complex chemical method involving many technical problems and the cost of its installation is quite high. According to one recent estimate by an engineering firm, it costs approximately two million dollars (total investment) to build a solvent plant with a capacity of 300 tons per day. Moreover, the newly created problem of selling soybean oil, which is one of the joint products of soybean processing, could be a difficult one in the face of accumulated surpluses of edible oils.

In view of these problems, the backward integration from feed mixing to soybean processing would be quite limited to cases where nonintegrated feed mixing firms have big feed operations which warrant either constructing a solvent plant or acquiring an existing processing mill. Or already-integrated feed firms may want to add another solvent plant to their operations.

During World War II, and in the immediate postwar years, soybean oil prices were quite high and soybean meal was scarce. This provided a good reason for feed mixers to enter soybean processing operations. In fact in those years soybean processing itself was quite a profitable operation with no problem of surplus oil. The combination of feed mixing with soybean processing was a very logical means of increasing business and profit.

In the case of cooperative processing plants, forward integration by country elevators was primarily motivated by the desire on the part of farmers to obtain soybean meal from their soybeans at the time of the shortage of high protein livestock feeds during and immediately after the war.

Vertical integration in oil. Advantages to processing firms, if any, of integrated operations toward end products of soybean oil are not at all clear. Theoretically there could be advantages that result from integrated operations by virtue of closer linking of supply, production, and marketing, but there seem to exist too many obstacles to encourage initiating such integration at the present time, either from processors or from manufacturers of edible oil products.

The obstacles are technological and financial and are also related to other problems of an economic nature. Compared with feed mixing, refining of oil and manufacturing of edible oil products such as margarine and shortening involve a higher degree of technological complexity and a necessity to satisfy the tastes and preferences of the consuming public. This kind of manufacturing requires costly equipment, and quality control is a much more difficult problem than in producing either soybean meal or mixed feeds.

In terms of marketing problems, "the marketing channels and type of direct consumer advertising needed for edible oil products were a great deal different from the marketing channels of meal and the use of meal by the mixed feed industry. In addition, the brands of margarine and shortening already in the market were fairly well established and competition would be difficult."[1]

In terms of location, soybean processing plants are not generally advantageously situated to manufacture edible oil products. While soybean processing is oriented to the source of the raw material, manufacturing of edible oil products is oriented to the market due to the high transport costs of finished products as contrasted to the low shipping rate of crude oil over long distances. Particularly in the case of margarine, the existence of a water content of nearly 20 percent makes it far more advisable to manufacture it at the market.

For the various reasons shown above, processors do not usually see any particular advantage in integrating forward to the end products of soybean oil. In rare instances where the difficulties cited do not exist or can be easily overcome, a processor may resort to this type of integration as a means of expansion. But such cases will be very limited in view of the better alternatives available to him in the direction of meal.

[1] Goldberg, R. A., *The Soybean Industry,* University of Minnesota Press, 1952, p. 71.

From the standpoint of manufacturers of edible oil products, as long as their raw material oils are available in abundance, there is no advantage in integrating backward to oilseed processing. Historically, when the supply of edible oils was scarce in and after World War II, some edible oil users started processing soybeans to secure a supply of soybean oil and to take advantage of the wide processing margins that prevailed during that period. But in the years that have followed this situation has changed entirely to one of accumulated surplus oils, and the advantage of the integration has even turned into a business burden in some cases. This change of circumstances is well illustrated in the following case where the Buckeye Cellulose Corporation, a subsidiary of Procter and Gamble, decided to sell four soybean crushing mills in 1958 to a large integrated feed manufacturing firm. Discussing the sale of their soybean plants, Buckeye President W. L. Lingle, Jr., said:

> "Buckeye entered the soybean crushing business primarily to supply Procter and Gamble with soybean oil for food products. Recently, however, the increasing importance of soybean meal for animal feed has made it desirable for soybean crushers to enter the mixed feed business. That's not Procter and Gamble's or Buckeye's kind of business, so it became sound business policy for us to buy soybean oil on the open market and to dispose of these facilities for crushing soybeans."[1]

Vertical integration in soybean acquisition. Sometimes soybean processors seem to be integrated backward to the level of country elevators. However, closer examination of these instances reveals that this type of integration is not exclusively for processing operations but is in principle a part of grain handling activities of integrated processors. If for processing requirements alone, this integration will prove to be a disadvantage to processors because of its fixed cost aspect, but in the context of integrated processing and grain marketing operations it may contribute to both processing and grain marketing through expanded facilities of grain handling and storage.

Small local processors may buy a large portion of their soybean requirements directly from farmers and probably retail their soybean meal or mixed feed to local livestock feeders. The economies thus realized are the basis of their existence in the face of the competitive power of larger and more efficient plants.

Horizontal integration in processing operations. The addition of like plants to a firm is a logical avenue for expansion. It was already deduced from our cost analysis that the decentralized areas of soybean production and decentralized markets make it highly advisable for a growing firm to operate several or more scattered plants rather than

[1] *The Soybean Digest,* December 1958, p. 5.

one of very large size. This is due mainly to the bulky nature of the raw material soybeans, the meal part of the joint product, or the mixed feeds in the case of integrated operations. The transport cost considerations put upper limits on the size of any one plant. This motivating force in the direction of horizontal integration is part of the nature of the processing business, and firms will continue to resort to this type of integration wherever and whenever economically and financially feasible to do so.

Processing of other oilseeds. The crushing of soybeans and other oilseeds involves similar technological and marketing problems. Where different types of oilseeds are readily available, as soybeans and cottonseed in the south and soybeans and linseed in the north, it is a natural path of expansion for a firm to combine processing of two or more kinds of oilseeds. Especially, with the recent technological development in solvent equipment capable of processing different oilseeds, the combined processing of cottonseed and soybeans or linseed and soybeans offers economic advantages to processing firms located in the areas where these oilseeds are produced. In combined operations firms can have some degree of flexibility in choosing the most profitable type of oilseed. Although this flexibility may be limited, combined operations will at least enable plants to run at a higher rate of capacity in the event of shortage of supply or where there is seasonal processing of one particular type of oilseed. The diversified activities would give the firms more stability in operation and earnings.

Effects of Integration

It has been shown in the above that vertical integration in soybean meal or horizontal integration of processing operations are economically the most feasible forms of integration in the soybean processing industry.

The main effect of the vertical integration, or for that matter also of the horizontal integration, would be the improvement of earning power, which in turn will result in keener competition in both the soybean processing industry and feed mixing industry. Under competitive conditions the economies realized should be conveyed all the way to the consumers of the end products concerned. These economies should also benefit producers of soybeans and other oilseeds with better prices for their products.

Firms operating several processing plants in various parts of the country have the advantage of adjusting their individual operations in

Table 24. — Share of Total Shipments Accounted for by Largest Companies in the Soybean Processing Industry, 1958 and 1947

Year	Companies[a]	Concentration ratio: Percentage of total value of shipments accounted for by[b]			Index of primary products specialization[c]
		4 largest companies	8 largest companies	20 largest companies	
	(number)		(percent)		(percent)
1958	66	40	63	86	87
1947	105	44	63	81	96

[a] Based on the 1945 Standard Industrial Classification so internal comparability is maintained.

[b] Percentages are sums of value of shipments of 4, 8, or 20 largest companies divided by the total value of shipments of the industry. The 4, 8, or 20 largest firms in the industry were not necessarily the same firms in both 1947 and 1958.

[c] Calculated by dividing the total value of the products primary to the industry by the industry's total value of shipments.

Source: *Concentration Ratios in American Industry,* report prepared by the Bureau of Census for the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary, U. S. Senate (87th Congress, 2nd session, 1962), Table 2.

line with the competitive position of different plant locations, thereby adequately coping with the changing circumstances of different locations.

From another standpoint, since horizontal integration promotes concentration of processing operations in fewer firms, the industry structure will be affected accordingly, although concentration of production in itself would not necessarily be conducive to less competitive conditions in the industry. The joint products of soybean processing can easily be replaced by similar products, and consequently, large integrated soybean processors can exercise no monopolistic influence upon prices of their products.

Table 24 shows the concentration of processing operations in the largest processing firms in the industry. The number of firms decreased greatly between 1947 and 1958, which confirms the industry trend in the past decade for fewer firms and fewer plants with larger capacities. It is interesting to note, however, that the share of the largest 4 firms declined slightly during the period, while the share of the largest 20 firms increased by 5 percent. The share of the 8 largest processors remained unchanged. But as a whole the share of the larger firms, most of which have multi-plant organizations, increased in the intervening years. One earlier study stated that in 1945 the 4 largest processors accounted for 40 percent of the total processing capacity in the United States, and the 8 largest accounted for 55 percent of it.[1]

[1] Shollenberger, J. W., and Gross, W. H., *Soybeans: Certain Agronomic, Physical, Chemical, Economic, and Industrial Aspects,* USDA Northern Regional Research Laboratory, Peoria, Ill., 1947, p. 55.

Summary and Probable Trends

The main purpose of this study was to describe the development and existing structure of the soybean processing industry in the United States. The study was pursued in the four major areas of interest as follows:

1. General review of the growth and development of the industry.
2. Cost analysis of soybean processing operations.
3. Locational analysis of soybean processing.
4. Business integration in the soybean processing industry.

In the first part of our study emphasis was placed on clarifying and describing the important economic, institutional, and technical factors that have contributed to the rapid development of the industry in the past few decades. The position of soybeans as an oilseed has been explored in terms of the supply-demand situation for edible fats and oils and high protein oilseed meals. The effect of the government farm programs and P.L. 480 exports upon production and utilization of soybeans was examined. The main trends and characteristics of the industry were fully explained in terms of underlying forces for them. Thus, the basis for our subsequent analyses was established in this first phase of our study of the industry.

Our cost analysis was concerned mainly with economies of scale in soybean processing operations and their effect upon organization of individual processors. It has been confirmed that there exist economies of scale in soybean processing operations. But as the size of the plant expands the processor must purchase his soybeans from a wider area and ship his products to a wider territory to keep his plant running throughout the year. This entails a higher cost of transporting his soybeans and soybean products. The combined effect of the physical economies of scale in processing operations, and external diseconomies of increasing marketing distance, tends to put upper limits on the size of any one plant. Therefore, an expanding soybean processing firm must find some means of coping with the external diseconomies of scale associated with the transportation cost of soybeans and soybean products in order to maximize net returns. Possible means of accomplishing this objective in the course of expanding processing activities were examined from the standpoint of both vertical and horizontal integration.

With respect to our locational analysis, transportation problems of soybean processing were explored in terms of economic and institutional factors. Price advantages and the transport cost situation generally determine the profitability of processing operations at different locations. A comparative study of the processing situation in different states was made and the findings were interpreted in terms of future potential for expansion in different regions of the United States.

Probable future trends. The United States, and for that matter the world as a whole, has relatively abundant supplies of edible fats and oils, while vegetable proteins to feed man and livestock animals are still in relatively short supply. Soybeans as an oilseed are low in oil content and high in protein in comparison with other oilseeds. This characteristic of soybeans is a definite advantage in meeting the need for more proteins and less fats and oils. It is expected that because of this advantage soybeans will continue to replace other oilseeds of higher oil content as a source of protein and oil. The industry processing this favorable oilseed can therefore expect a continued expansion of its processing operations in the future, although disposal of oil may become a limiting factor unless oil is competitively priced to substitute further for other fats and oils.

But this bright prospect for future expansion of the industry does not necessarily guarantee an equal rate of growth for every firm in the processing business. There are a number of factors involved here for each plant at a different location. The two major factors affecting the future potential are the cost structure and the location. In order to survive increasing competition resulting from higher efficiency of processing, handling, and transportation, each firm must make every effort to minimize its cost and share in the growth of the industry.

On the basis of our study we may expect that the effort of every processor to lower his cost will entail an enlargement of the average plant size in the industry. But as long as the market for soybean products continues to expand, such enlargement of size may not necessarily be accompanied by a decline in the total number of processing mills in the industry below the present level. It is expected, however, that small local plants of lower efficiency, as well as those mills which have no particular price advantage or transportation advantage, will find it increasingly difficult to operate profitably and expand their operations under competitive conditions. Meanwhile, well-integrated feed mixers and soybean processors will continue to expand both horizontally and vertically through purchase of existing feed mills or processing plants, or by building new plants at favorable locations.

In the long run it is most reasonable to expect that a relatively greater expansion of processing operations will take place in regions having either a comparative price advantage or a transportation advantage or both. Such areas are the states surrounding Illinois, particularly Missouri, Ohio, Minnesota, and Mississippi. As soybean production continues to increase in the south and southeast, coupled with the increase in livestock and poultry population, a favorable processing situation is likely to prevail in the southern states in general.

Developments in the structure of freight rates, particularly as they accelerate the current tendency to reduce the importance of the transit privilege, will be especially important in the location of new plants. We should expect these developments to increase the number of plants locating near the source of raw material.

A future consideration in locating soybean processing plants may be access to overseas markets for soybean products, as the United States will continue to export substantial quantities of soybean oil and meal in addition to soybeans. Ohio, and locations along the Mississippi and its tributaries, especially in the south, are likely to attract new plants.

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