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THE DEMAND AND PRICE STRUCTURE FOR FOOD FATS AND OILS WITH EMPHASIS

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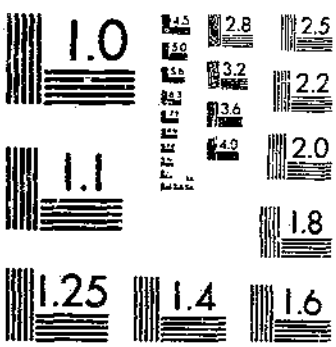

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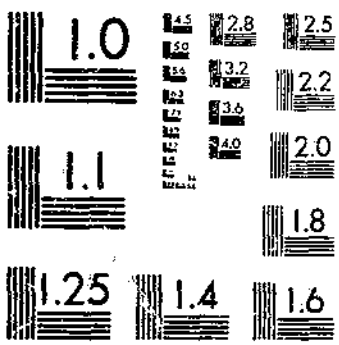

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NATIONAL BUREAU OF STANDARDS-1963-A

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WASHINGTON, D. C.

The Demand and Price Structure for Food Fats and Oils[1]

With Emphasis on Analyses Designed to Measure the Effects of Increased Yields of Cottonseed Oil on Prices and Total Returns

By SIDNEY J. ARMORE [2]
Agricultural Economic Statistician
Bureau of Agricultural Economics

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[1] Submitted for publication February 17, 1953.

[2] Mr. Armore is now Supervisory Economist with the United States Department of Labor, Washington, D. C.

SUMMARY

Major edible fat and oil products, in order of relative consumption, are lard (used directly as lard), shortening, butter, salad and cooking oils, and margarine. Total per capita consumption of these items has been relatively stable during the last 30 years. A decrease in the use of fatty spreads for bread has been about offset by an increase in the use of salad and cooking oils. Most of the butter and lard is consumed in the same form in which it is produced. Other edible fat and oil products are produced from a variety of fats and oils, of which the two most important are soybean oil and cottonseed oil. During the last two decades, use of cottonseed oil in such products has been relatively stable, but use of soybean oil has increased sharply, particularly since around 1940.

The competitive relationships among food fats and oils are different for users of edible fat and oil products than for manufactures of these products. Users, principally households, restaurants, and bakeries, buy shortening, margarine, cooking and salad oils, mayonnaise and salad dressings, lard, and butter. In the users' market, these products compete with each other. However, as ingredients in the manufacture of these products, competition is almost wholly among food fats and oils other than butter and lard. In these uses, butter and lard neither compete with each other nor, to any appreciable extent, with other food fats and oils. Competition of edible oils with butter and lard is almost entirely *indirect*, through their use as ingredients in the manufacture of margarine and shortening. Such oils compete *directly* with each other as ingredients in the manufacture of edible fat and oil products.

Consumption of margarine varies more or less directly with the price relationship between butter and margarine, particularly after allowing for the long-term upward trend for margarine and the downward trend for butter. However, when the factors that affect prices of food fats and oils other than butter and lard were analyzed, it was found that changes in the supply of butter apparently had no statistically significant effect on these prices during the period included in the analysis.

A close relationship exists between consumption of lard and consumption of (vegetable) shortenings. When consumption of one declines, consumption of the other tends to rise. The statistical analysis previously referred to indicated that, for the years included in

the analysis, a 1-percent change in the supply of lard had about two-thirds as much effect on the price of edible fats and oils, other than butter and lard, as did a 1-percent change in the supply of these items as such. Thus it is clear that there is a direct competitive relationship between these two groups of fats and oils. Reflecting a number of factors discussed in this report, the retail value of lard has shown a declining percentage of the total retail value of lard and shortening since the early 1920's. Owing mainly to concerted action on the part of the lard industry, this trend may have been reversed in 1951.

During the 1920's and the early 1930's, cottonseed oil was the leading ingredient used in edible fat and oil products. Coconut oil (now used largely in soap and certain industrial products) and corn oil were next in importance. In these years, most of the cottonseed oil was used as the major ingredient in shortening. The bulk of the coconut oil used in edible products was used in margarine. Corn and olive oils were the leading competitors of cottonseed oil in food uses other than shortening and margarine. Imposition of the 3-cent-a-pound processing tax on coconut oil in 1934, together with the enactment of numerous State laws taxing margarine that contained non-domestic fats and oils more heavily than other margarine, materially reduced the use of coconut oil in this product. A few years later, domestic production of soybean oil began to increase rapidly, reflecting in part Government acreage-control programs for corn, wheat, cotton, and peanuts in the late 1930's and favorable prices during World War II.

With these developments, cottonseed oil largely replaced coconut oil in margarine, and the increasing supply of soybean oil was directed chiefly to use in shortening. In addition, soybean oil was used to a greater extent than formerly in margarine and other food products. Use of coconut oil in food products now is confined mainly to certain specialized uses for which domestic fats and oils are not well suited. In some years, substantial quantities of soybean oil are used in drying-oil products and substantial quantities of lard are used in soap.

Two types of demand exist for most fats and oils. One has to do with the minimum amounts or proportions that manufacturers believe must be used to give the standardized products they desire. In the minds of manufacturers, there is no substitute for these minimum amounts of the particular oil they use in manufacturing a specific product. The other has to do with the remaining requirements for fats and oils. They are selected for these requirements mainly on the basis of price and available supply. These two types of demand may be thought of as noncompetitive and competitive, respectively. Year-to-year variations in the proportionate amounts of cottonseed oil, for example, used in leading fat and oil products indicate that the competitive demand for cottonseed oil cannot be ignored. The high proportionate use of cottonseed oil in these products, even when prices of this oil are unusually high in comparision with those for other fats and oils, indicates that the noncompetitive demand for cottonseed oil must be considered also.

When the supply of cottonseed oil is larger than the demand for its noncompetitive use, the excess may be considered part of a special commodity group of fats and oils. This group includes supplies of other food fats and oils, excluding butter and lard, which are in excess of any noncompetitive demand that may exist for them. The close

agreement between price changes for cottonseed oil and those for other edible vegetable oils indicates that cottonseed oil usually competes with other food fats and oils as an ingredient in the manufacture of certain products. As it is not possible to separate the total supply of an individual fat or oil into its excess and noncompetitive supplies, a study of the relationship between the price and the supply of any single oil must be directed toward the price-supply relationship for food fats and oils, other than butter and lard, as a group.

The equivalent-price of an edible fat or oil, as used in this bulletin, is the price of the crude fat or oil plus all the costs incurred in transporting, processing, and using it in the manufacture of a particular product. When it is immaterial to a manufacturer which of a number of fats and oils he uses in his product, their equivalent-prices must be equal if they are to be competitive. Price margins at the crude, f. o. b. mill level that result in identical equivalent-prices for two or more fats and oils differ from product to product, from manufacturer to manufacturer, and from time to time. Average price margins that prevail during a given marketing year are such as to result in the complete utilization of available supplies of each fat and oil, after allowing for exports and carry-over.

In an analysis of the factors that affect prices of food fats and oils other than butter and lard, the three variables—per capita supply of fats and oils used in food products (other than butter and lard), per capita supply of lard, and personal disposable income—explained 92 percent of the variation in prices for 1922–42 and 1947–51. On the average, a 1 percent change in the supply of these fats and oils was associated with a change of 1.6 percent in the opposite direction in price. Thus the demand for edible fats and oils at the wholesale level is "inelastic." On the average, a 1 percent change in the supply of lard was associated with a 1.1 percent change in the opposite direction in prices of edible fats and oils. Based on these relationships, a 1-pound change in the per capita supply of lard would be expected to have about as much effect on the price of edible fats and oils, excluding butter and lard, as does a 0.9-pound change in the per capita supply of these fats and oils. A 1-percent change in per capita disposable income, on the average, was associated with a change of 1.4 percent in the same direction in price.

Residuals from this analysis apparently follow a pattern that is related to changes in the dependent variable. This would be expected, with the changes in inventory and purchase practices that are known to occur as a result of changes in the trend in prices of fats and oils. Thirty-eight percent of the variation in prices unexplained by the three independent variables included in the analysis was associated with year-to-year changes in these prices. Thus, when prices of fats and oils rise, actual prices would be expected to be at a higher level than that indicated by the analysis; when prices fall, actual prices would be expected to be at a lower level than that indicated by the analysis.

Production of cottonseed oil may increase or decrease as a result of several circumstances. Among these are changes in acreage planted to cotton, in the yield of cottonseed, in the quantity of cottonseed retained for planting the following year's crop, or in the method of processing the seed for oil and meal. Relationships given in this

report were developed particularly for use in measuring the probable effects of the adoption of oilseed processing methods that result in higher yields of oil on gross returns to the cottonseed-crushing industry and to growers of cottonseed and other oil-bearing materials. The Production and Marketing Administration is preparing a report on the types of new cottonseed crushing plants that will be most feasible and the probable economic effect of the adoption of such plants upon returns to the industry and to growers of cotton. Their report will use the equations developed in the present study that show the supply-demand relationship for cottonseed oil and the effect of change in the value of major cottonseed products per ton of seed processed on the season average price of cottonseed paid to growers. An increase in the yield of oil resulting from improved processing methods would not affect the yield of meal, as this yield is regulated by mixing in additional quantities of hulls.

Three relationships that are of value in this connection are developed in this bulletin. The first, which has been discussed, shows how an increase in production of cottonseed oil would affect the wholesale price of edible fats and oils. A separate equation is used to show what effect this price has on the price of cottonseed oil.

The second relationship estimates the effect of changes in the value of the major cottonseed products obtained per ton of seed processed on the season average price of cottonseed paid to growers. An increased yield of oil, for example, would increase the value of the seed but this would be offset in part by the lower price obtained for the oil.

The third relationship estimates the effect of changes in the price of cottonseed on the percentage of the cottonseed crop, less use for planting, sold to mills. Increases in the price of cottonseed tend to increase slightly the percentage of the crop sold.

These analyses provide a framework by which the probable effects on prices and returns to farmers and the cottonseed-processing industry of the adoption of certain processing methods for cottonseed can be measured.

INTRODUCTION

Three agencies of the U. S. Department of Agriculture—the Production and Marketing Administration, the Farm Credit Administration, and the Bureau of Agricultural Economics—are conducting a joint study under the Agricultural Marketing Act of 1946 (RMA, Title II) to ascertain the effects on the price of cottonseed products sold by oil millers and the price and total returns from cottonseed sold by farmers that would accompany the partial or complete adoption by cottonseed-oil mills of methods and equipment that would most improve their economic position. The Bureau of Agricultural Economics has the responsibility, under this project, of determining the relationship between the price and the supply of cottonseed oil and of outlining methods by which the effect on the price of cottonseed oil and on total returns to growers and processors of an increase in the supply of oil can be estimated.

These methods, and the economic and statistical reasoning on which they are based, are presented here. Background material developed under another project is included to provide an understanding of the

economic forces that affect the cottonseed industry. A similar report by Simon (*12*) [3] on soybeans is being published concurrently.

THE FOOD FATS AND OILS ECONOMY

Edible fats and oils, including butter, represent more than 60 percent of the total consumption of all fats and oils in the United States. In order of relative consumption, the major products are: Lard used directly as lard, shortening, butter, salad and cooking oils, and margarine. Figure 1 shows the per capita consumption of these items from 1922 through 1951. Total consumption of lard and shortening (the two major cooking fats) was relatively stable, and the consumption of shortening increased in years in which production of lard was small. Consumption of butter declined sharply during the early part of World War II and tended to follow a declining trend in other years. This decline was only partially offset by an increase in the consumption of margarine. Consumption of salad and cooking oils followed a generally rising trend after about 1933. Consumption of all food fats and oils has been relatively stable during the last 30 years.

Most of the butter and lard is consumed in approximately the same form in which it is produced. Other edible fat and oil products (shortening, margarine, and salad and cooking oils) are produced from a variety of edible fats and oils, including some lard. The two major items included in these products are soybean oil and cottonseed oil. The use of cottonseed oil in edible products has been relatively stable since 1931 (the earliest year for which detailed statistics are available), but the use of soybean oil has increased sharply, particularly since about 1940. The use of other food fats and oils has been relatively stable. During the 1930's, substantial quantities of oils used mainly in nonfood products, such as coconut and palm, were used in food products. During World War II, the available supplies of these oils were channeled to vitally needed nonfood products. In the postwar years, the large supplies of domestic edible oils, available at comparatively low prices, displaced a large percentage of the nonfood oils previously used in food (fig. 2).

A characteristic feature of fats and oils is interchangeability. Individual fats and oils may be best suited for specific uses, but most fats and oils can be used for a variety of products. For example, the four major products in which fats and oils are utilized are: Food products, soap, drying-oil products, and miscellaneous industrial products. Individual fats and oils can be classified according to the leading use to which they are put. Cottonseed oil, soybean oil, and lard are considered food fats, because they are used chiefly as food or in the manufacture of food products. Coconut oil and inedible tallow are used largely in making soap; linseed oil is used largely as a drying oil. However, these fats and oils are used in other products as well. For example, coconut oil is used in food products and for various industrial purposes other than soap, and soybean oil is used to a considerable extent in products that require drying oils.

Figure 3 shows the principal economic forces that are believed to affect food fats and oils other than butter and lard. Prices of this commodity group are affected by a number of factors. One set includes the supply of lard and possibly the supply of butter. Both of

[3] Italic figures in parentheses refer to Literature Cited, p. 45.

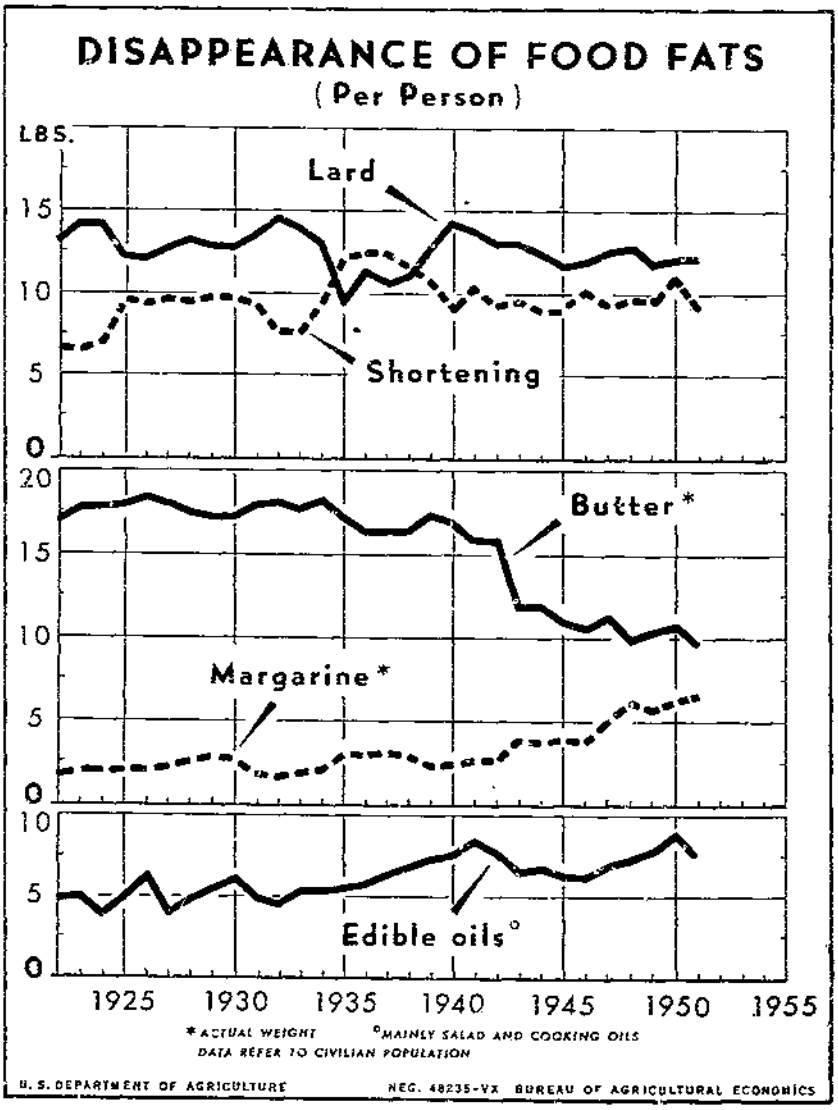

FIGURE 1.—Total consumption of food fats has been fairly stable during the last 30 years. No trends have been evident with respect to the major cooking fats. The decline in consumption of fatty spreads for bread has been about offset by an increase in the consumption of salad and cooking oils.

these commodities compete in the consumers' market for edible fat and oil products. A second set includes factors that affect the demand for raw materials for use in soap, drying-oil products, and other industrial products. These factors affect the price of food fats and oils as follows:

If the supply of soap fats or of drying and industrial oils is low and demand is high, manufacturers of these industrial products look to

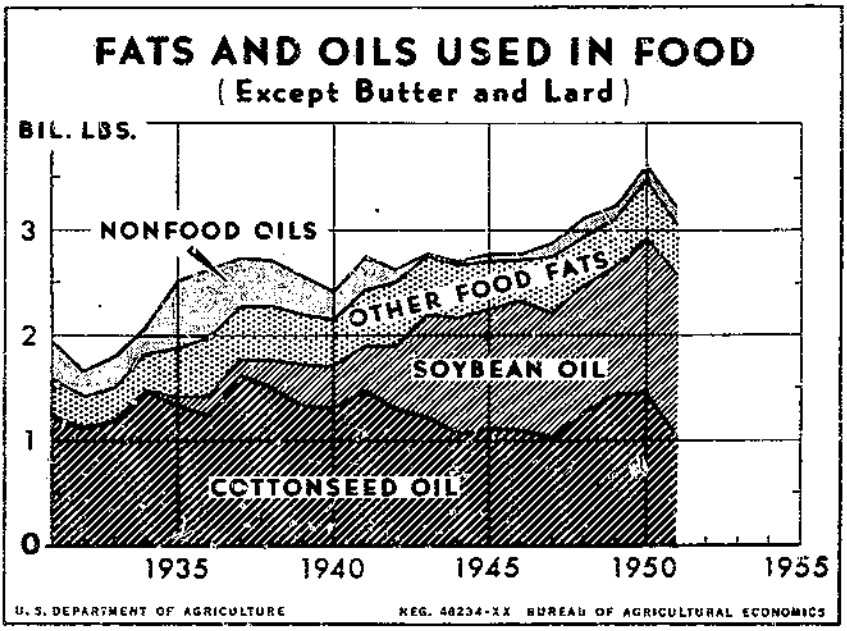

FIGURE 2.—Use of soybean oil in food products increased sharply in the last decade, reflecting mainly a phenomenal increase in the domestic production of soybeans. Since 1943, the use of nonfood oils in food products has been comparatively small. During World War II, these oils were used mainly in vitally needed nonfood products. More recently, they have been displaced by the large supplies of domestic edible oils.

food fats and oils to make up the deficiency in supply, thereby bidding up their price.

Other factors include the supply of food fats and oils, other than butter and lard, consumer income, and the demand for storage and export. Foreign demand for *all* fats and oils other than butter is included as a factor in determining the price of fats and oils other than lard and butter, because the principal uses of fats and oils in foreign markets differ to some extent from their utilization in this country. For example, whale and linseed oils are practically always used in nonfood products in the United States. In certain other countries, however, they are used mainly in food products. The relationships involved in this diagram are discussed in greater detail in later sections of this bulletin.

DEMANDS FOR DOMESTIC CONSUMPTION, EXPORT, AND STORAGE

The dashed arrows in figure 3 indicate the physical flow of the supply of food fats and oils other than butter and lard into the three channels: Domestic disappearance (consumption), exports, and stocks. These outlets represent three separate demands. Domestic consumption is affected by consumer income, average prices of the several fats and oils included in the group, and the prices of related commodities in the consumers' market, such as lard. Exports of these products are affected by domestic prices for these fats and oils and foreign demand

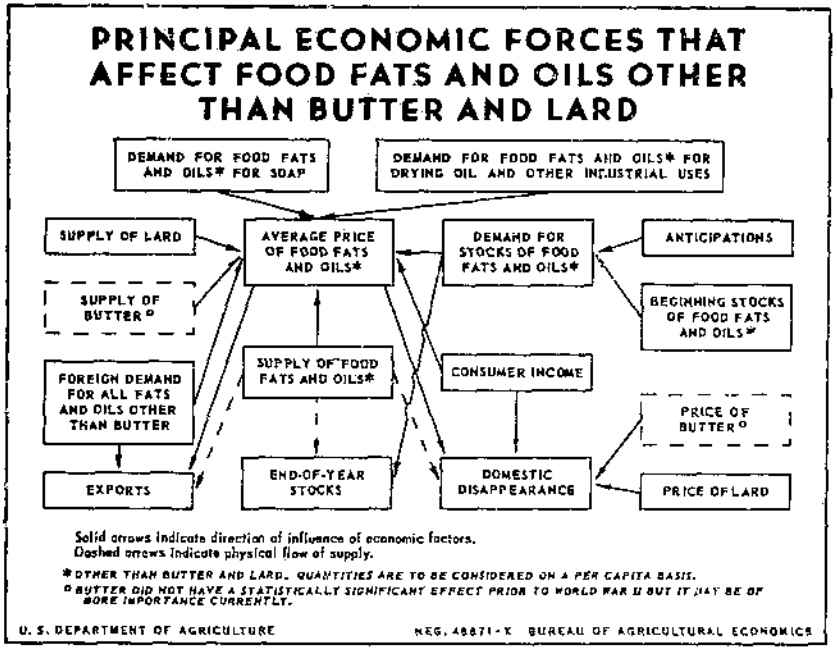

FIGURE 3.—This chart presents a simplified diagram of the economic relationships that affect the price and demand for food fats and oils other than butter and lard. It may be considered as a part of a larger diagram covering the entire fats and oils economy. The numerous relationships of the factors indicated in the chart are discussed in some detail in the text.

for all fats and oils other than butter. Year-end stocks are influenced by anticipations of conditions of supply and demand in the year ahead and inventories on hand at the beginning of the year.

Statistical analysis for 1921–42 indicates that, on a per capita basis, a 1-pound increase in the supply of fats and oils used in food products (other than butter and lard) tended to increase domestic consumption 0.66 pound; stock holdings, 0.23 pound; and exports, 0.10 pound. That is, during these years, about 66 percent of a given increase in the supply of fats and oils used in food products per capita tended to go into domestic disappearance. From 1943 to 1951, changes in stocks and exports were more important. For these years, a 1-pound increase in supply tended to increase domestic consumption 0.36 pound; stock holdings, 0.35 pound; and exports, 0.29 pound.[4]

These relationships have a bearing upon the effect of an increase in the supply of oil on its price. If the additional supply of oil were to go entirely toward increasing the domestic disappearance of food fats and oils, prices would decline sharply, as domestic demand for total edible fats and oils is highly inelastic. The tendency for prices to decline with an increase in supply is reduced, as part of the additional supply flows into larger exports (or reduced imports) and into inventory accumulations.

[4] See Appendix note 3, p. 51.

Competitive Relationships Among Food Fats and Oils

As discussed above, food fats and oils logically fall into three groups: Butter, lard, and other edible fats and oils. Butter and lard are ordinarily used directly by households and bakeries. Before 1936, minor quantities of butter were used in margarine. Relatively small quantities of lard are used in shortening, margarine, and nonfood products (table 1). Other food fats and oils are used principally as ingredients in shortening, margarine, cooking and salad oils, and mayonnaise and salad dressings. Smaller quantities are used in other food products such as confections and potato chips, and in canning fish.

Fats and oils other than lard and butter that are or have been important in the food field are mainly of vegetable origin. Chief among these are cottonseed, soybean, and coconut oils. Edible tallow and oleo oil are the leading animal fats and oils in this group, but they are less important than the minor vegetable oils, such as corn and peanut oil.

Cottonseed and soybean oils are the leading ingredients in shortening and margarine.[5] In other food products, principally cooking and salad oils, mayonnaise, and salad dressing, the leading oils used are cottonseed, corn, and soybean oils. Peanut oil is of lesser importance. Olive oil was important as a salad oil before the outbreak of World War II. However, its price is considerably higher than prices of the other oils mentioned.

The competitive factors that govern the use of food fats and oils by users and by manufacturers of edible fat and oil products differ. Households, restaurants, and bakeries buy edible fat and oil products, such as shortening, margarine, cooking and salad oils, mayonnaise and salad dressings, lard, and butter. In the users' market, competition is primarily between butter and margarine and between lard and shortening, although some substitution occurs among other fat and oil products. For example, in some households butter or margarine may be used interchangeably with lard, shortening, and cooking oils for such purposes as frying.

But the competition for fats and oils used as ingredients in the manufacture of these products and for other purposes, such as in confectioneries, fish canning, and potato-chip making, is almost wholly among food fats and oils other than butter and lard. In these uses, butter and lard do not compete with each other nor, to any appreciable extent, with other food fats and oils.

Therefore, competition of the edible oils with butter and lard through their use as ingredients in the manufacture of fat and oil products, principally margarine and shortening, is almost entirely *indirect*. As ingredients in the manufacture of edible fat and oil products, such oils compete *directly* with each other.

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[5] Since 1940, use of lard in shortening, as reported by the Bureau of the Census, has increased. Just before 1940, lard made up less than 1 percent of the total fats and oils reported used in shortening; in 1940-46, it made up between 1 and 5 percent; and in 1947–50, 7 to 10 percent. This use of lard is believed to represent chiefly use in a shortening product composed of a high percentage of lard plus other fats. For purposes of this report, it is convenient to consider this shortening product as a form of lard, instead of considering this use of lard as a competitor of vegetable oils in production of shortening.

TABLE 1.—*Major fats and oils used in food: Domestic disappearance, and utilization by major classes of products, averages, 1932–51*

Commodity and period	Domestic disappearance	Percentage of domestic disappearance				
		Food use				Nonfood use [2]
		Shortening	Margarine	Other food use [1]	Total	
		BUTTER				
Average:	*Million pounds*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1932–36	2,229	0	(3)	100	100	0
1937–41	2,195	0	0	100	100	0
1948–51	1,558	0	0	100	100	0
		LARD				
Average:						
1932–36	1,582	.2	.4	99.4	100.0	(3)
1937–41	1,659	.9	.2	98.9	100.0	(3)
1948–51	2,041	7.7	.2	90.2	98.1	1.9
		OTHER FOOD FATS AND OILS				
Cottonseed oil						
Average:						
1932–36	1,376	67.7	4.3	19.7	91.7	8.3
1937–41	1,552	62.2	8.8	22.2	93.2	6.8
1948–51	1,428	30.4	28.8	31.8	91.0	9.0
Soybean oil						
Average:						
1932–36	85	40.9	3.7	26.8	71.4	28.6
1937–41	400	42.9	15.3	23.2	81.4	18.6
1948–51	1,654	45.2	19.5	17.1	81.8	18.2
Corn oil						
Average:						
1932–36	129	1.4	.3	85.5	87.2	12.8
1937–41	164	.5	.5	88.6	89.6	10.4
1948–51	224	.4	.3	90.8	91.5	8.5
Peanut oil						
Average:						
1932–36	60	65.5	5.5	20.7	91.7	8.3
1937–41	98	54.4	2.6	36.7	93.7	6.3
1948–51	123	20.9	2.4	64.7	88.0	12.0
Tallow, edible						
Average:						
1932–36	83	96.4	0	.2	96.6	3.4
1937–41	90	61.6	(3)	35.4	97.0	3.0
1948–51	66	29.1	.1	67.4	96.6	3.4
Oleo oil						
Average:						
1932–36	60	1.4	28.5	66.9	96.8	3.2
1937–41	76	.8	18.6	79.9	99.3	.7
1948–51	46	1.0	7.6	90.8	99.4	.6

See footnotes at end of table.

TABLE 1.—*Major fats and oils used in food: Domestic disappearance, and utilization by major classes of products, averages, 1932–51*—CON.

Commodity and period	Domestic disappearance	Percentage of domestic disappearance				
		Food use				Nonfood use [2]
		Shortening	Margarine	Other food use [1]	Total	
		OTHER FOOD FATS AND OILS—continued				
Oleostearine	*Million pounds*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Average:						
1932–36	39	61.2	8.4	27.7	97.3	2.7
1937–41	42	60.5	7.8	30.3	98.6	1.4
1943–51	29	42.5	11.1	46.1	99.7	.3
Olive oil, edible						
Average:						
1932–36	69	0	0	99.6	99.6	.4
1937–41	53	0	0	99.7	99.7	.3
1948–51	43	(3)	0	99.6	99.6	.4
		NONFOOD OILS				
Coconut oil						
Average:						
1932–36	597	3.6	24.2	13.9	41.7	58.3
1937–41	604	3.3	8.4	20.1	31.8	68.2
1948–51	560	2.7	.3	15.9	18.9	81.1
Palm oil						
Average:						
1932–36	253	27.3	.2	6.5	34.0	66.0
1937–41	275	34.3	.4	6.6	41.3	58.7
1948–51	48	1.5	0	0	1.5	98.5

[1] Includes fats and oils sold to bakers and other food manufacturers.
[2] Including "foots," the residue from refining.
[3] Less than 0.05 percent.

From Bureau of the Census, Bureau of Internal Revenue, and U. S. Department of Agriculture. Domestic disappearance computed from data on production, factory and warehouse stocks, imports, and exports (including shipments to United States Territories in the case of lard). Beginning with 1949, all data are on an as-reported basis. For prior years, stocks and imports and exports of refined oils are included on a crude basis. Use in margarine, prior to June 1950, Bureau of Internal Revenue, after June 1950, Bureau of the Census; other uses based mainly on factory consumption, Bureau of the Census. Difference between domestic disappearance and total factory consumption included in "other food use."

RELATION OF BUTTER TO OTHER FOOD FATS AND OILS.—Butter is known to compete with margarine as a spread for bread. This competition is difficult to measure statistically, in part because margarine, and to a lesser extent, butter, also compete with shortening and other fats and oils for cooking and frying. Consumption of margarine varies more or less directly with the price relationship between butter and margarine.

In analyzing the factors that affect prices of food fats and oils, other than butter and lard, for this study, changes in the supply of butter appeared to have no statistically significant effect during the period included. For this reason, the supply of butter was omitted from the analysis. With the increased importance of margarine in recent years, it is possible that changes in the supply of butter may currently affect prices of edible vegetable oils. From 1920 to 1940, the ratio of consumption of margarine to consumption of butter was 0.14; and from 1950 to 1951, the ratio was 0.62.

Relation of Lard to Other Food Fats and Oils.—As indicated in figure 1, a close relationship exists between consumption of lard and consumption of vegetable shortenings. When supplies of lard were short during the mid-1930 droughts, consumption of lard declined and that of shortening increased. Less evidence is available as to whether a reverse shift takes place. In any case, the statistical analysis referred to above indicated that, for the years included in the analysis, a 1-percent change in the supply of lard had about two-thirds as much effect on the price of edible fats and oils, other than butter and lard, as did a 1-percent change in the supply of these items as such. Thus it is clear that there is a direct competitive relationship between these two groups of fats and oils.

The retail value of lard has represented a declining percentage of the total retail value of lard and shortening since the early 1920's. During the peak year 1923, the retail value of lard accounted for 67 percent of the total value of both fats, whereas in 1950, it accounted for only 39 percent. If allowance is made for the increased use of lard in shortening, the figure for 1950 would be 44 percent. Both prices and consumption of lard declined in relation to those of shortening. Several factors are believed to have been of importance in bringing about this shift in consumer preference. One was the lack of uniformity in lard, both from packer to packer and from different renderings of the same packer. Shortening, at least for any given brand, is quite a uniform product. Some manufacturers of shortening have advertised heavily and have packed their product in hermetically sealed metal cans. Under normal conditions, shortening in cans will keep indefinitely prior to opening. Also, it can be stored conveniently in the original container until it is used. Lard usually is packed in lightweight cardboard containers.

Housewives apparently prefer a general-purpose shortening. To make satisfactory cakes with lard, special recipes are required and those published by manufacturers of shortening are designed to give satisfactory results only with shortening. Renderers of lard are trying to reverse this trend by marketing a product that contains a high percentage of lard but acts like a typical vegetable shortening. It is packed in cans similar to those used for advertised brands of household shortening and is called by a brand name that bears no resemblance to lard. Special blends of lard, with or without hydrogenated vegetable oils, also are prepared for use in specified types of commercial baking. A third measure adopted by renderers of lard to popularize their product is to improve both the quality and method of packaging lard. For example, addition of a small quantity of lard flakes results in a product that will keep satisfactorily without refrigeration.

In 1951 the percentage of the total retail value of lard and shortening represented by the retail value of lard increased to 47 percent,

not allowing for lard used in shortening, and to 53 percent after this adjustment. The increase probably reflected in part the large demand for lard for export and in part the effects of improved methods of preparing and merchandising lard.

USE OF OTHER FATS AND OILS IN FOOD PRODUCTS.—The numerous uses possible for most fats and oils and the extent to which one can be replaced by another results in a high degree of competition among these commodities in the market. The relative utilization of individual fats and oils in margarine, shortening, and other edible fat and oil products has shifted. These shifts reflect several influences, including advances in technology relating to fats and oils, trends in relative supplies of fats and oils available on the market, and Government policies and regulations.

TABLE 2.—*Major fats and oils used in food products (other than lard and butter): Percentage distribution of supply, 1920–51*

Year	Supply								Use in food products of other fats and oils [1]		Use of food fats in nonfood products [1]	Net total [2]
	Cottonseed oil	Soybean oil	Corn oil	Peanut oil	Olive oil, edible	Oleo oil	Tallow, edible	Oleo stearine and oleo stock	Coconut oil	Other		
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1920	67.7	7.9	5.2	5.7	1.7	6.5	1.9	3.4	4.4	1.1	5.5	100.0
1921	75.8	2.1	4.6	2.9	2.5	7.2	2.0	3.4	4.0	1.5	6.0	100.0
1922	65.9	1.4	7.0	2.2	3.5	8.9	2.7	4.9	6.3	2.5	5.3	100.0
1923	65.2	2.5	6.8	.8	4.5	9.0	2.9	4.8	7.2	1.4	5.7	100.0
1924	68.9	.9	6.4	1.1	4.0	7.9	2.6	4.8	6.1	3.4	6.1	100.0
1925	75.5	1.0	4.8	.9	3.8	6.3	2.1	4.0	4.9	3.2	6.5	100.0
1926	76.8	1.3	5.0	.8	3.2	6.3	2.3	3.8	5.6	1.8	6.9	100.0
1927	80.8	.9	4.8	.6	2.8	5.0	1.8	3.1	5.9	1.0	5.7	100.0
1928	77.6	.9	5.4	.7	3.2	4.7	1.6	2.8	7.4	1.6	5.0	100.0
1929	74.8	1.2	5.6	.8	3.5	4.6	1.6	2.6	9.6	1.5	5.8	100.0
1930	73.4	1.3	4.9	1.5	3.4	4.2	1.5	2.4	10.7	2.7	6.0	100.0
1931	71.8	2.1	4.7	1.5	2.9	4.1	2.7	2.2	7.7	5.6	5.3	100.0
1932	80.0	2.1	4.7	.8	2.8	2.8	2.1	1.8	6.3	2.8	6.2	100.0
1933	78.4	1.6	5.4	.6	2.6	3.2	2.1	1.8	7.3	2.7	5.7	100.0
1934	77.5	1.8	5.6	1.8	2.2	3.1	2.8	1.6	7.5	1.4	5.3	100.0
1935	62.1	4.3	4.8	4.7	2.3	2.5	2.5	1.8	10.8	2.4	5.2	100.0
1936	57.6	7.7	5.2	4.4	2.0	3.0	3.5	2.0	8.4	10.0	4.7	100.0
1937	68.2	7.6	5.2	3.7	1.5	2.2	2.7	1.6	5.6	7.4	5.1	100.0
1938	60.6	10.6	4.8	3.2	2.1	2.6	2.8	1.5	6.1	5.6	5.9	100.0
1939	61.9	15.1	5.4	2.0	2.1	2.3	2.8	1.3	4.9	6.0	4.7	100.0
1940	62.1	18.3	5.8	3.2	1.9	2.3	2.6	1.3	4.9	3.4	5.8	100.0
1941	58.8	19.2	6.4	5.6	.8	2.8	2.9	1.6	5.5	3.9	7.5	100.0
1942	66.0	25.8	8.9	3.6	.6	3.3	3.9	1.9	1.1	2.4	7.5	100.0
1943	40.3	37.6	7.5	4.9	.5	2.4	3.0	1.2	0	.9	8.2	100.0
1944	46.2	41.7	6.0	4.9	.2	1.8	3.0	1.1	0	1.5	8.2	100.0
1945	48.3	41.9	6.2	4.4	.4	1.6	3.4	.8	0	1.9	8.9	100.0
1946	43.4	40.6	6.3	4.4	.5	1.0	2.3	.6	1.1	1.0	9.6	100.0
1947	40.1	40.0	7.6	4.8	.5	1.5	2.9	1.1	3.5	.4	11.4	100.0
1948	45.3	45.5	5.6	4.5	1.0	1.1	2.0	.8	3.4	1.4	10.6	100.0
1949	47.7	46.1	5.5	4.5	.7	1.2	2.0	.8	2.4	.6	11.5	100.0
1950	43.2	47.7	5.6	3.7	1.8	1.3	1.8	.8	3.8	1.0	10.7	100.0
1951	35.5	55.3	5.3	4.1	1.0	1.0	1.6	.7	3.7	.9	9.1	100.0

[1] Based on rough estimates prior to 1931.
[2] Total supply of fats and oils used mainly in food, plus use in food of other fats and oils, less use of food fats in nonfood products.

Bureau of the Census and Bureau of Agricultural Economics.

Table 2 shows the percentage distribution of the supply of the major fats and oils, other than butter and lard, used in food products. The total, which represents 100 percent on this table, equals the total supply of fats and oils (other than butter and lard) used mainly in food prod-

ucts, plus the use in food products of other fats and oils, such as coconut and palm oil, less the use of food fats and oils in nonfood products. From 1920 to 1933, cottonseed oil represented 65 to 80 percent of this total. In most of these years, the use of coconut oil in food products was the second most important item, although in a number of years the supply of corn oil was about as large. Prior to 1935, the supply of soybean oil was negligible.

From 1920 to 1933, the bulk of the supply of cottonseed oil was utilized in production of shortening; it made up from 80 to more than 90 percent of the total fats and oils consumed for this purpose (table 3). Other outlets were in margarine and in food uses other than shortening and margarine (tables 3 and 4). The latter uses represent principally cooking and salad oils, mayonnaise, and salad dressings. Increasing per capita consumption of lettuce, especially during the 1920's, and probably a rising trend in per capita consumption of other salad items, has tended to increase the importance of these uses as outlets for fats and oils. An additional factor has been the increasing use of what was originally a southern custom of spreading sandwiches with mayonnaise or creamed salad dressing instead of with butter or margarine, coupled with the increased sale of sandwiches at drug stores and lunch counters. From 1920 to 1933, corn and olive oils were the leading competitors of cottonseed oil in food uses other than shortening and margarine.

TABLE 3.—*Fats and oils used in margarine and shortening: Percentage distribution, averages 1920–51*

Item	Cottonseed oil	Soybean oil	Peanut oil	Coconut oil	Oleostearine	Lard	Oleo oil	Palm oil	Edible tallow	Other fats and oils	Total fats and oils
Shortening:[1]	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Average:											
1920–23	84.0	0.9	2.5	1.6	5.6	1.4	(2)	(3)	1.8	2.2	100.0
1929, 31–33	84.8	.4	.3	1.5	2.4	.9	(2)	1.9	4.3	3.5	100.0
1934–40	69.0	8.2	3.6	1.5	1.9	.4	(2)	6.5	5.3	3.5	100.0
1941–46	44.2	38.4	4.0	.6	1.8	2.8	(2)	1.4	4.4	2.4	100.0
1947–51	27.2	50.0	2.4	2.1	.9	0.8	(2)	(4)	1.7	5.9	100.0
Margarine:[1]											
Average:											
1920–25	10.3	(4)	5.2	39.3	2.5	14.8	24.7	(2)	(2)	3.2	100.0
1926–33	9.7	.1	2.0	62.5	2.2	7.4	14.3	(2)	(2)	1.8	100.0
1934–40	39.2	12.9	1.1	33.7	1.2	1.3	5.7	(2)	(2)	4.8	100.0
1941–46	48.8	38.7	1.6	2.4	.7	1.8	3.5	(2)	(2)	2.5	100.0
1947–51	56.0	39.4	.9	.8	.5	.6	.6	0	0	1.2	100.0

[1] 1920–23 and 1929, U. S. Tariff Commission (*19*, pp. 160–161); 1931–51, reports of the Bureau of the Census. Data not available for 1924–28 and 1930.
[2] Included in other fats and oils.
[3] Not reported separately.
[4] Less than 0.05 percent.
[5] 1920 and 1921, calendar-year average of fiscal-year data; 1922–June 1950, compiled from monthly data published in reports of the Bureau of Internal Revenue; July 1950–date, from Bureau of the Census.

From 1920 to 1933, the bulk of the coconut oil consumed in edible products was utilized in the manufacture of margarine. This oil accounted for 35 to 75 percent of the total fats and oils used in margarine. In the early part of this period, cottonseed oil, oleo oil, and neutral lard were important, although relatively declining, ingredients used for this purpose.

The decline in the use of cottonseed oil, lard, and oleo oil in margarine from 1920 to 1933 reflects the shift by many manufacturers from products containing cottonseed oil and animal fats to all-

vegetable-oil products using mainly coconut oil. According to Snodgrass (*14*, ch. 12), utilization in margarine production of a hydrogenated mixture of coconut oil and a small percentage of another vegetable oil, usually peanut oil, resulted in a product with improved texture, especially in warm weather. Other fats and oils made up relatively minor proportions of the total fats and oils utilized in production of margarine from 1920 to 1933.

TABLE 4.—*Liquid oils used in food products other than shortening and margarine: Percentage distribution, averages 1931–51* [1]

Period	Cottonseed oil	Corn oil	Peanut oil	Soybean oil	Olive oil	Sesame oil	Total oils
Average:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1931–40	53. 1	21. 9	3. 5	7. 3	12. 5	1. 7	100. 0
1941–46	46. 4	21. 7	5. 0	25. 0	1. 7	. 2	100. 0
1947–51	42. 6	19. 8	7. 0	26. 4	3 6	. 6	100. 0

[1] Includes mainly use in the manufacture of salad and cooking oils, mayonnaise, and salad dressing, and also use by bakers and other food manufacturers, such as confectioners, potato-chip manufacturers, and fish canners.

Estimated by the Bureau of Agricultural Economics based mainly on reports of the Bureau of the Census.

Since 1933, owing to a number of circumstances, the relative utilization of fats and oils in margarine, shortening, and other food products has shifted. In the early and middle 1930's many States enacted laws that taxed margarine containing nondomestic fats and oils more heavily than other margarine. The chief nondomestic ingredient of margarine was coconut oil. Under the Internal Revenue Act of 1934, a tax of 3 cents a pound was imposed on the first domestic processing of coconut oil produced in the Philippines or from copra produced in the Philippines. An additional tax of 2 cents a pound was imposed on the first domestic processing of other coconut oil, but this was largely ineffective, as imports from other countries were reduced to a negligible rate in most years. These taxes became effective May 10, 1934.

The droughts of 1934 resulted in ruined acreages of corn and other crops early in the season and led to sharp increases in the acreage planted to soybeans. Reduction in acreages planted to corn, wheat, cotton, and peanuts, under the acreage-control program, led to increased plantings of soybeans as an alternative crop in the second half of the 1930's. The favorable price and marketing conditions that existed during World War II resulted in further large increases in the acreage of soybeans. In addition, development of improved varieties and other factors resulted in increasing yields per acre.[6] Consequently, domestic production of soybeans and soybean oil expanded rapidly after the middle 1930's, particularly during World War II.

For these and other reasons, relative supplies of the major edible fats and oils in the domestic market have shifted considerably since 1933. The percentage of the total represented by cottonseed oil declined almost steadily after 1933 to 35 percent in 1951 (table 2).

[6] See Strand (*15*).

This decline was a reflection of acreage controls for cotton and an expanding production of soybeans. The supply of soybean oil increased steadily to 55 percent of the total in 1951. Use of coconut oil in food products declined after 1935, dropping to zero in certain years during World War II when supplies were diverted to more essential uses under orders of the War Food Administration. Since 1947 the amount of coconut oil used in food products has been from 2 to 4 percent of the supply variable for all fats and oils (excluding butter and lard) used in food products. Similar shifts occurred for some of the less important fats and oils.

As a result of the tax incentives for the use of domestic fats and oils in margarine, the relative decline in the supply of cottonseed oil, the sharp rise in the supply of soybean oil, and the rapid improvement in equipment and methods of processing soybean oil, major shifts occurred after 1933 in the relative utilization of edible fats and oils in the manufacture of individual products. Cottonseed oil largely replaced coconut oil in margarine, as it is the favored domestic oil for this use. Consumption of cottonseed oil in shortening declined rapidly because it was used to an increased degree in the manufacture of margarine and also because of its declining supply as a percentage of the total. The increasing supply of soybean oil was used largely for the manufacture of shortening. In addition, soybean oil was used to a greater extent than formerly in margarine and other food products.

Supplies of coconut oil available to the United States were greatly reduced during World War II because of the occupation of the Philippines by Japan. Use of coconut oil in margarine had been materially reduced following the imposition of the 3-cent processing tax in 1934 but it represented 34 percent of all fats and oils so used from 1934 to 1940. During the war years, when no coconut oil could be used in margarine, manufacturers found that they could make a product with better spreading properties from hydrogenated cottonseed and soybean oils. Unlike most fats, coconut oil does not soften gradually with increasing temperature. It is inclined to pass rather abruptly from a brittle solid to a liquid within a temperature range of a few degrees. A further disadvantage of coconut oil in products used for cooking is the tendency it has to make the product foam and sputter. These properties tend to restrict the use of coconut oil in food products such as margarine and shortening.

For other food products, coconut oil is not only desirable but practically essential. Coconut oil is used for coatings by both confectioners and bakers because coatings must be nongreasy at ordinary temperature but must melt quickly in the mouth. Biscuit makers use coconut oil for making fillings for such products as sweetened wafers. Certain popular unsweetened crackers require a coating of fat on the outside surface. This enriches the cracker and imparts a characteristic glossy appearance. Coconut oil is superior to domestic oils for this purpose because it has less tendency to turn rancid. It is estimated that in the early 1950's, 100 to 125 million pounds of coconut oil were used annually for such purposes.[7] Since the war, most of the coconut oil in the United States has been used in soap or for specialized industrial purposes.

[7] See Simplification of Customs Administration, (*18*, p. 21).

USE OF FOOD FATS AND OILS IN NONFOOD PRODUCTS.—In certain years substantial quantities of fats and oils ordinarily used mainly in food are used in nonfood products. Quantities used are determined largely by economic forces which are not directly related to food fats and oils. For example, more than 150 million pounds of soybean oil were used in drying-oil products in each year from 1947 through 1949. Before 1947, the greatest quantity that had been used in any year was 67 million pounds. The large usage during those years may be accounted for mainly by the high Government support price provided for flaxseed and the wide margin thus resulting between the prices of linseed and soybean oils. Use of soybean oil in drying-oil products was moderately lower in 1950 and 1951. Similarly, substantial quantities of lard were used in soap during certain months in which the demand for inedible tallow and grease was unusually large in relation to the supply. As a result, prices of inedible tallow equaled or exceeded those for grades of lard which were of equivalent value to the soapmaker.

COMPETITIVE AND NONCOMPETITIVE DEMANDS FOR A SINGLE COMMODITY

Notwithstanding the high degree of interchangeability among certain fats and oils as ingredients in shortening, margarine, and other food products, their physical and chemical characteristics differ. Some of these differences affect the taste, odor, and other qualities of the products in which they are used. Some affect the degree and nature of the processing required when a fat or oil is used in manufacturing other products.

Because of these differences, formulas used by individual manufacturers of fat and oil products differ with respect to the proportions of animal and vegetable fats and oils used and, in all-vegetable-oil products, in the proportions of individual oils used. Formulas used by a single manufacturer for a specific product also may vary from time to time.

Several considerations enter into the making up of formulas. These include the physical and chemical properties of individual fats and oils, the size and relative steadiness of the year-to-year supply, relative prices, and the producer's knowledge of and experience in the use of individual fats and oils. Factors that decide the relative use of cottonseed and soybean oils are emphasized in this and the following section. Similar principles would apply with respect to other fats and oils.

COTTONSEED OIL IN FORMULAS FOR FOOD PRODUCTS

Producers of shortening, margarine, and other food products frequently sell branded items. They try to maintain uniformity with respect to taste, texture, color, and other qualities to which their customers have become accustomed. Although formulas are adjusted to some extent to reflect relative prices, available supplies, and other factors, manufacturers as a rule are apparently reluctant to make any marked changes in formulas. This may reflect a reluctance both to alter production routines and to risk affecting the specific quality of their products.

A major factor in making up formulas is the general belief by the industry that certain minimum quantities or proportions of cottonseed oil are needed to produce an all-vegetable-oil shortening or margarine of good quality. In the present stage of fat and oil technology, especially processing techniques, this may be true. The quantities or proportions of cottonseed oil believed to be required undoubtedly vary among manufacturers.

Limitations on interchangeability of fats and oils in part are determined by their origin. For example, vegetable oils could not be used interchangeably with animal fats in an all-vegetable-oil product. There are limitations with respect to proportions used in specific products also. A manufacturer of shortening or margarine who requires a certain proportion of cottonseed oil in his product may use several fats and oils interchangeably for the remainder.

Competitive and Noncompetitive Demands for Cottonseed Oil

Manufacturers of edible fat and oil products have two types of demand for cottonseed oil. First, there is the demand made by the manufacturer who uses minimum quantities or proportions of cottonseed oil; and second, the demand for cottonseed oil made by the manufacturer after he has satisfied his minimum requirement.

In the mind of the manufacturer, there is no substitute for the cottonseed oil he uses to satisfy his minimum requirement. For the oil used over and above his minimum requirement for cottonseed oil, he can use fats and oils other than cottonseed oil—soybean oil, peanut oil, corn oil, edible tallow, oleostearine, and possibly others. These he selects on the basis of relative prices and available supplies. This demand may be designated the competitive demand for cottonseed oil.

Within the competitive segment of a manufacturer's demand, the several fats and oils that he chooses solely on the basis of relative prices and availability may be thought of, in an economic sense, as perfect substitutes.

Demand for cottonseed oil may be divided conveniently into competitive and noncompetitive demand. It is recognized that, in practice, there may be shades in between. For a part of his fat and oil use, a manufacturer may feel that he must have cottonseed oil regardless of price. For another part, he may prefer cottonseed oil and he may be willing to pay a premium to obtain it for this use but he may not feel that it is absolutely essential. For the third part of his requirements, his choice may depend almost entirely on the price of cottonseed oil as compared with other oils. Manufacturers may have similar minimum requirements for other fats and oils. For example, a manufacturer may feel that he must use a certain proportion of both cottonseed and peanut oil in his product, and that for the remainder he may choose among these and other fats and oils solely on the basis of price and availability.

Year-to-year variations in the proportionate use of cottonseed oil in margarine, shortening, and other food products indicate that the competitive demand for cottonseed oil cannot be ignored. The high proportionate use of cottonseed oil in these products, even when prices of this oil are unusually high in comparison with those for other fats and oils, indicates that the noncompetitive demand for cottonseed oil must, likewise, be considered.

Application of the Double-Demand Relationship to Analyses of Factors That Affect Prices of Cottonseed Oil [8]

One purpose of the study upon which this report is based was to investigate the effect on the price of cottonseed oil of a change in its supply. When the supply of cottonseed oil is larger than the demand for its noncompetitive use, the excess may be considered a part of a special commodity group. This group includes, as well, supplies of other food fats and oils, excluding lard and butter, that are in "excess" of any noncompetitive demand that may exist for them. From the standpoint of the competitive demand for cottonseed oil, these excess supplies are as much a part of the supply of cottonseed oil as is the excess supply of this oil itself.

For theoretical convenience, the supply of cottonseed oil may be segregated into two parts—the supply for noncompetitive uses and the residual supply for competitive uses. The proportion of the total supply of cottonseed oil that goes into each of these segments each year is not known. In certain years, supplies of cottonseed oil may be short and only the noncompetitive segment of demand may be met. This cannot be determined statistically as the quantity or proportion of cottonseed oil that each manufacturer thinks he must have in his product varies among manufacturers and from time to time for each manufacturer. However, the substantial year-to-year changes in the proportionate use of cottonseed oil and the close agreement between price changes for cottonseed oil and for other edible vegetable oils indicate that cottonseed oil usually competes with other food fats and oils as an ingredient in the manufacture of specific products.

In an investigation of the relationship between the supply of cottonseed oil and its price, the excess supplies of other edible fats and oils (excluding butter and lard) must be added to the supply of cottonseed oil. In general, an increase in the excess supply of cottonseed oil would be expected to have the same effect on the price of cottonseed oil as an increase in the excess supply of any other fat or oil in the group. As it is not possible to separate the total supply of any fat or oil into its excess and noncompetitive supplies, a study of the relationship between price and supply of cottonseed oil must be directed toward the price-supply relationship for food fats and oils, other than butter and lard, as a group.[9]

A consideration of the dual nature of the demand for cottonseed oil will be helpful in obtaining an understanding of the price relationships between cottonseed oil and other food fats and oils. The competitive segment of the demand for cottonseed oil, considered in connection with the concept of equivalent prices, provides the key to these price relationships.

THE CONCEPT OF EQUIVALENT PRICE

The *equivalent-price* of an edible fat or oil is the price of the crude fat or oil plus all the costs incurred in transporting, processing, and using it in the manufacture of a particular product. These costs vary among fats and oils. When it is immaterial to a manufacturer which

[8] For a more technical discussion of double-demand relationships, see Appendix note 1, p. 46.

[9] See Appendix notes 1 and 5, p. 46 and p. 56.

of a number of fats and oils he uses in his product, their equivalent prices must be equal if they are to be competitive.

Factors That Affect Margins Among Prices of Individual Fats and Oils

When the costs involved in processing and using a particular fat or oil are greater than the costs of using cottonseed oil for the purpose, the crude price of the particular fat or oil must be lower than the price of cottonseed oil, if the two are to be competitive in the market. But if these costs are lower for a particular fat or oil than for cottonseed oil, the price of cottonseed oil must be lower if they are to be competitive. Therefore, it is to be expected that prices of food fats and oils used principally as ingredients in edible fat and oil products will fluctuate up and down together and that average price margins will reflect differences in the costs involved in transporting, processing, and using it in manufacture.

Under only one condition could the price of cottonseed oil fluctuate independently of prices of other fats and oils that are normally competitive with it. This could occur only when the supply of cottonseed oil is so small, compared to the noncompetitive demand for it, that there is no excess supply to compete with other food fats and oils as an ingredient. In such an event, cottonseed oil becomes an independent commodity—that is, a commodity with no substitutes. Manufacturers would then be willing to pay any reasonable price to obtain this oil for use in their products, regardless of the price of other fats and oils.

But even when the supply of cottonseed oil is small and no excess supply is in sight to compete with other fat and oil ingredients, a higher equivalent price for this oil might prove to be only temporary. Pressures likely to develop in the market would tend to bring about adjustments that would make the equivalent prices of cottonseed oil and other food fats and oils, other than butter and lard, equal.

Cottonseed and soybean oils are the leading ingredients in shortening, margarine, and other edible fat and oil products. If a short supply of cottonseed oil results in a higher equivalent price for it than for soybean oil, it would be to the advantage of manufacturers to shift to soybean oil as far as possible. Some manufacturers are more enterprising than others and have greater "know-how" in using soybean oil. Although they may require a certain minimum quantity of cottonseed oil in their products, they are able to use larger quantities of soybean oil than others and they do so whenever this is to their advantage. When this happens, others are compelled to utilize greater quantities of soybean oil than they ordinarily prefer if they wish to offer their products to consumers at competitive prices. It is probable that the minimum quantity of cottonseed oil that many manufacturers think they need in their products is flexible. Under pressure of competition, these manufacturers may find that they can substitute more soybean oil for cottonseed oil than they at first thought possible.

This results in an increasing demand for soybean oil, which in turn operates to pull up its price. But as manufacturers shift their demand to the cheaper soybean oil and away from the more expensive cottonseed oil, the demand for cottonseed oil is reduced. This operates to

pull down the price of cottonseed oil. As these prices are pulled toward each other, the price of soybean oil upward and the price of cottonseed oil downward, the spread between them tends to stabilize at the point at which their equivalent prices under existing conditions of supply are equal.

A bumper cottonseed crop, on the other hand, accompanied by "normal" supplies of other fats and oils, might result in a psychological reaction in the market that would initially weaken the price of cottonseed oil and drive its equivalent-price below that for other fats and oils, such as soybean oil.

As has been emphasized before, cottonseed oil is the preferred ingredient in certain edible fat and oil products; a drop in its equivalent price, therefore, would result in its increased utilization. Producers who for some purposes could just as well use soybean oil would tend under these conditions to shift to the less expensive cottonseed oil. The strong demand for cottonseed oil would operate to pull its price upward, while the reduced demand for soybean oil would pull its price downward, and the spread between their prices would tend to stabilize at the point at which their equivalent prices are equal.

The average price margin between cottonseed oil and other edible fats and oils at a crude f. o. b. mill level, which results from differences in the costs of transporting, processing, and using these fats and oils in manufacturing, may be expected to vary from period to period. This variation reflects, among other factors, shifts in the relative availabilities of oils and fats and the extent to which each is used in products by manufacturers. As processing costs vary among producers, the price margins required to make these fats and oils competitive differ likewise. In other words, the price margin between unrefined cottonseed oil and another fat or oil, which results in equal equivalent prices, is smaller for some manufacturers than for others.

More processing of a certain fat or oil may be required for use in one product than for use in another. Thus, the price margin that results in equal equivalent prices differs from product to product, even for the same manufacturer. Further, as the price margin between cottonseed oil and other food fats and oils (not including butter and lard) reflects relative costs in processing and using these fats and oils in the manufacture of products, it is influenced by changes in labor and other charges that make up these costs. That is, price margins tend to move up and down with changes in the general price level.

Prices of crude oils are generally quoted f. o. b. crushing mills. Thus, margins between quotations on crude oil prices for the various oils also reflect variations in transportation costs. Because of the geographic location of the largest refiners and manufacturers, most of the fat and oil products are processed in the Northern States, from Chicago eastward, although some of the important refineries and manufacturing plants are in other parts of the country. When supplies of soybean oil are large, prices of crude soybean oil must be depressed more than the usual amount in relation to cottonseed oil to enable the oil to move to more distant manufacturing plants, as their equivalent-prices must be equal at the plant.

When supplies of soybean oil are small relative to those of cottonseed oil, the bulk of the soybean oil may be used in plants near the soybean-oil areas, and cottonseed oil may be used for competitive purposes in plants farther from the cottonseed-crushing area. This alone would

cause the price of crude soybean oil to be higher than normal in relation to the price of crude cottonseed oil, when both prices are quoted on an f. o. b. mill basis, in years for which supplies of soybean oil are relatively small.

This discussion of the factors that affect margins among prices of individual fats and oils may be summarized as follows: (1) If the equivalent-prices for two or more competitive fats and oils for use in a specific product, by a particular manufacturer, at a given time are not equal, he will tend to use more of the lower (equivalent) priced fat or oil and less of the higher-priced one. This action, of itself, will tend to equalize the equivalent-prices; (2) price margins that result in identical equivalent-prices for two or more fats and oils differ from product to product, from manufacturer to manufacturer, and from time to time; (3) average price margins that prevail during a given marketing year will be such as to result in complete utilization of available supplies of each fat and oil after allowing for exports and carry-over.[10] A discussion of the relationship between prices of cottonseed oil and those of soybean oil in terms of equivalent-prices is presented in a subsequent section.

Statistical Analyses Related to This Concept

On the basis of the competitive relationships discussed in connection with the food fats and oils economy, fluctuations in the wholesale price of cottonseed oil would be less closely related to changes in prices of butter and lard than to changes in prices of other food fats and oils. But, in view of the various factors that affect the price margins between cottonseed oil and other food fats and oils (not including butter and lard), their price movements would not be perfectly associated.

Statistical analyses of these price relationships have been made for the period 1922–40.[11] These analyses confirm the relationships expected. About 66 percent of the year-to-year variation in the wholesale price of cottonseed oil in 1922–40 was associated with year-to-year variation in average wholesale prices of other food fats and oils, excluding butter and lard, after adjusting these prices for changes in the general wholesale price level.

After allowance had been made for changes in the general wholesale price level, it was found that about 40 percent of the year-to-year variation in the wholesale price of cottonseed oil was associated with year-to-year variation in the wholesale price of lard. This relationship undoubtedly reflects, at least partly, the fact that during the period covered, 1922–40, cottonseed oil was the leading ingredient used in shortening, which competes directly with lard. A similar analysis for cottonseed oil and butter indicated that, during the same period, no relationship existed between the wholesale prices of these products. This is reasonable, as the price of butter is determined to a greater extent by conditions in the dairy industry than by factors of supply and demand relating to other fats and oils.

The analyses indicated also that, after adjusting for changes in the general price level, a 1-cent per pound increase in the price of food fats

[10] In terms of economic theory, the prevailing price margins will be determined in such a way that the equivalent-prices will be equal for the marginal use in the marginal plant of the marginal manufacturer at any given time.

[11] See Appendix note 4, p. 52.

and oils, other than cottonseed oil, butter, and lard, in 1922–40, was accompanied by a similar increase in the price of cottonseed oil. Thus, no matter how high or how low these wholesale prices were in 1922–40, they tended to differ by a constant margin, when the effects of changes in the price level are taken into account. Based on the discussion of equivalent-prices, this would be expected.

Although the analyses indicated that wholesale prices of cottonseed oil and lard moved up and down together to some extent during 1922–40, a 1-cent per pound increase in the price of lard was accompanied on the average by an 0.4-cent per pound increase in the price of cottonseed oil. That is, the wholesale price of lard, during 1922–40, fluctuated more widely than the wholesale price of cottonseed oil.

Price Relationships Between Cottonseed and Soybean Oils [12]

The chief competitor of cottonseed oil is soybean oil. Cottonseed oil is preferred for certain uses, and manufacturers have had many years of experience with it. As an important ingredient in edible fat and oil products, soybean oil is a relative newcomer. It is generally believed in the industry that soybean oil cannot completely replace cottonseed oil in shortening, margarine, or other edible products, although some all-soybean-oil products are made.

Table 5.—*Cottonseed and soybean oils: Wholesale prices and price margins, 1935–51*

Year beginning August	Wholesale price per pound			
	Cottonseed oil, crude, tank cars, f. o. b. Southeastern mills	Soybean oil, crude, tank cars, f. o. b. Midwestern mills	Margin	
			Actual	Deflated [1]
	Cents	*Cents*	*Cents*	*Cents*
1935	8. 6	7. 3	1. 3	1. 3
1936	9. 2	[2] 8. 9	. 3	. 4
1937	6. 6	[3] 5. 8	. 8	. 8
1938	6. 0	5. 0	1. 9	1. 0
1939	5. 6	5. 0	. 6	. 7
1940	6. 5	6. 1	. 4	. 4
1941	12. 3	11. 0	1. 3	1. 1
1942	12. 8	11. 8	1. 0	. 8
1943	12. 8	11. 8	1. 0	. 7
1944	12. 8	11. 8	1. 0	. 7
1945	12. 8	11. 8	1. 0	. 7
1946	24. 8	22. 1	2. 7	1. 5
1947	26. 2	22. 8	3. 4	1. 7
1948	15. 4	14. 8	. 6	. 3
1949	12. 5	11. 8	. 7	. 4
1950	20. 4	17. 8	2. 6	1. 3
1951	13. 0	11. 9	1. 1	. 5

[1] Actual margin divided by the Bureau of Labor Statistics index of wholesale prices of all commodities (1935–39=100).

[2] 11-month average.

[3] 10-month average.

Prices compiled from Oil, Paint and Drug Reporter (*9*).

[12] This section sketches briefly the wholesale price relationships between cottonseed and soybean oils in terms of the previous discussion of competitive relationships and equivalent-prices. Detailed analysis of price relationships among food fats and oils is planned for a later publication.

ANNUAL PRICE MARGINS.—Table 5 presents average wholesale price margins between crude cottonseed and soybean oils for 1935–51 (years beginning August). Margins varied from 0.3 to 3.4 cents a pound during this period, averaging 1.2 cents a pound for 1935–40 and 1946–49. During most of the time from December 1941 to July 1946, margins did not fluctuate freely, because of price controls. When the influence of changes in costs due to changes in the general price level are removed,[13] fluctuations in price margins are considerably reduced. Deflated margins varied from 0.3 to 1.7 cents a pound in 1935–51, averaging 0.8 cent a pound in 1935–40 and 1946–49.

From 1940 to 1950 (omitting 1943–45 when price controls were in effect), 85 percent of the variation in the deflated margin was associated with changes in the supply (production plus August 1 stocks) of cottonseed oil (table 6). Although the number of years on which this relationship is based is small, a correlation of this size would be obtained less than 1 percent of the time by chance if no relationship between the two variables existed. Based on the discussion of equivalent-prices and the factors that affect price margins, a relationship

TABLE 6.—*Acreage and production of cottonseed and soybeans, and production, stocks, and exports of cottonseed and soybean oil, 1930–52*

Year	Year beginning August					Year beginning October				
	Cottonseed		Cottonseed oil			Soybeans		Soybean oil		
	Acreage in cultivation, July 1	Production	Factory production	Stocks, Aug. 1	Exports	Acreage [1]	Production [2]	Factory production	Stocks, Oct. 1	Exports
	Mil. acres	*1,000 tons*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*	*Mil. acres*	*Mil. bu.*	*Mil. lb.*	*Mil. lb.*	*Mil. lb.*
1930	43	6,625	1,442	372	28	3	14	35	13	5
1931	39	7,310	1,694	307	43	4	17	40	16	3
1932	36	5,815	1,448	705	44	4	16	29	17	1
1933	40	5,511	1,393	779	23	4	14	26	11	2
1934	28	4,256	1,109	741	5	6	23	78	15	4
1935	28	4,631	1,164	597	4	8	49	209	14	4
1936	31	5,472	1,364	362	4	7	34	134	39	5
1937	34	7,844	1,961	485	8	7	45	276	36	7
1938	25	4,050	1,499	555	5	9	62	416	57	7
1939	25	4,869	1,325	574	21	11	90	533	45	18
1940	25	5,286	1,425	568	16	12	78	564	80	14
1941	23	4,553	1,250	346	8	11	107	707	68	21
1942	23	5,202	1,401	308	63	15	188	1,206	111	44
1943	22	4,988	1,236	246	9	16	190	1,249	200	59
1944	20	4,992	1,324	288	8	14	192	1,347	203	67
1945	18	3,664	1,018	351	0	14	193	1,415	216	74
1946	18	3,514	973	306	8	12	203	1,531	199	91
1947	22	4,682	1,276	190	35	14	186	1,534	212	115
1948	23	5,045	1,394	128	85	13	227	1,807	96	300
1949	28	6,559	1,847	195	147	12	234	1,937	113	291
1950	19	4,105	1,107	215	61	15	299	2,454	113	490
1951	28	6,286	1,748	167	149	14	282	2,441	171	271
1952	26	6,108	------	402	------	14	202	------	104	------

[1] Acres grown alone, with an allowance for acreage grown with other crops.
[2] Soybeans harvested for beans.

Acreage and production of oilseeds compiled from reports of the Bureau of Agricultural Economics; factory production, stocks, and exports of cottonseed and soybean oil from Bureau of the Census. Stocks of cottonseed and soybean oil are crude plus refined converted to crude through 1947; beginning 1948, crude and refined are added as reported. Cottonseed oil exports, 1930–47, crude plus refined converted to crude, 1948-date crude plus refined without converting. Soybean oil exports prior to January 1943, crude and refined not separately reported used as crude; 1943–47 crude plus refined converted to crude; 1948-date crude plus refined without converting.

[13] Influence of the general price level was removed by dividing the actual margins by the Bureau of Labor Statistics index of wholesale prices for all commodities (1935–39=100). These are called deflated margins.

of this type would be expected. A similar relation apparently did not exist before 1940. This may reflect the fact that supplies of soybean oil in those years were small, so that prices of soybean oil less accurately reflected general supply-demand relationships for edible fats and oils.

MONTHLY PRICE MARGINS.—Table 7 presents monthly wholesale prices of crude cottonseed and soybean oils and price margins for 1937 and 1947 (years beginning July). These years were chosen because of special circumstances which might have been expected to cause some deviations from normal in the price margins.

The acreage planted to cotton was larger in 1937 than in the three previous seasons (table 6). The 1937 cottonseed crop was the second largest on record; it came at a time when stocks of cottonseed oil were substantial. Acreage and production of soybeans and soybean oil rose likewise in the 1937 season, but the supply of soybean oil was small relative to the supply of cottonseed oil. Because of the abundant supply of cottonseed oil in 1937–38 its price dropped appreciably, thus narrowing the price margin between cottonseed oil and soybean oil. In October 1937, this price margin was 0.3 cent a pound; from October 1937 to March 1938, it varied from 0.3 to 0.7 cent a pound (table 7).

TABLE 7.—*Cottonseed and soybean oils: Wholesale prices and price margins, 1937 and 1947* [1]

Season beginning July	Wholesale price per pound							
	1937				1947			
	Cottonseed oil	Soybean oil	Margin		Cottonseed oil	Soybean oil	Margin	
			Actual	Deflated [2]			Actual	Deflated [2]
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
July	8.0	-------	-------	-------	22.2	17.2	5.0	2.7
August	7.0	-------	-------	-------	18.5	15.9	2.6	1.4
September	6.2	-------	-------	-------	20.6	18.8	1.8	.9
October	6.1	5.8	0.3	0.3	21.4	20.7	.7	.4
November	6.0	5.6	.4	.4	26.6	25.6	1.0	.5
December	5.9	5.2	.7	.7	26.9	26.2	.7	.4
January	6.2	5.8	.4	.4	28.0	26.6	1.4	.7
February	6.7	6.1	.6	.6	22.2	19.6	2.6	1.3
March	7.0	6.4	.6	.6	23.9	21.4	2.5	1.3
April	6.9	5.9	1.0	1.1	29.2	24.5	4.7	2.4
May	7.0	5.7	1.3	1.4	34.6	26.3	8.3	4.1
June	6.8	5.2	1.6	1.6	35.4	27.3	8.1	3.9

[1] Cottonseed oil price—crude, tank cars, f. o. b. Southeastern mills. Soybean oil price—crude, tank cars, f. o. b. Midwestern mills.

[2] Actual margin divided by Bureau of Labor Statistics wholesale price index for all commodities (1935–39=100).

Prices compiled from Oil, Paint and Drug Reporter (*9*).

The narrowing of the margin between the price of cottonseed oil and that of soybean oil probably resulted in a lower equivalent-price for cottonseed oil than for soybean oil for most uses. This tended to bring about an increased utilization of cottonseed oil. The strong demand for cottonseed oil strengthened its price in later months and

the reduced demand for soybean oil was accompanied by a falling price. As a result, from April to June 1938, the margin widened from month to month, reaching 1.6 cents a pound in the latter month. This widening in the margin probably also reflected the sharp cut in acreage of cotton in 1938 and the concern among manufacturers of fat and oil products that the supply of cottonseed oil would be substantially smaller in the 1938–39 marketing year.

Production and stocks of cottonseed oil generally declined during World War II. At the beginning of the 1947 crop year, stocks of cottonseed oil were the lowest since 1923. Acreage planted to cotton in 1947 was low, although larger than for the three previous seasons. The cottonseed crop and the production of cottonseed oil were larger than for the two previous years. However, in view of the domestic and world shortages of fats and oils, the supply of cottonseed oil available during 1947–48 was not considered large. During this season, the acreage of soybeans was higher than that of the previous season and production was lower, but the season's production of soybean oil added to the carryover made available a greater supply than that of the previous year. During 1947–48 exports of both cottonseed oil and soybean oil were considerably higher than they were the previous year, as a result of the world shortage of fats and oils and the Economic Cooperation Administration program, which was inaugurated in April 1948.

The cottonseed oil-soybean oil price margin varied from 0.7 cent to 8.3 cents a pound from July 1947 through June 1948. When deflated, the price margin varied from 0.4 cent to 4.1 cents a pound.

In July 1947 the price margin was high, amounting to 2.7 cents a pound (deflated). This probably reflected a temporary squeeze before the new-crop oil became available in volume. The price margin (deflated) declined to 1.4 cents a pound in August and varied from 0.4 to 0.9 cent a pound from September 1947 to January 1948, rising to 1.3 cents a pound in February to March 1948.

From April to June 1948, the price margin widened, varying from 2.4 to 4.1 cents a pound (deflated). This probably reflected the large supplemental export allocations announced in March 1948. Exports of cottonseed oil had been large since October 1947. This reduced the supply of cottonseed oil available for domestic consumption, causing considerable concern among manufacturers of margarine, shortening, and other edible fat and oil products. The price margin between cottonseed and soybean oils widened materially; as a result of the short supply of cottonseed oil, no excess supply was available to compete with soybean oil or other food fats and oils as ingredients in edible fat and oil products. The available supply of cottonseed oil was taken up for noncompetitive uses.

FACTORS THAT AFFECT PRICES OF FOOD FATS AND OILS OTHER THAN BUTTER AND LARD

Analyses of the quantitative effects of specified factors on the prices of a group of closely related commodities are useful from several standpoints. Such analyses indicate the relative effects of each major factor taken separately and the total part of the variation in prices that can be explained by the several factors taken together. An analysis of all food fats and oils (except butter and lard) showed that

a major part of the variation in prices for this group may be accounted for by the supplies of this group of fats and oils, the supplies of lard, and consumer income. This would be expected, as a result of the findings outlined in preceding sections. If estimates are available of the probable level of the supply variables and of consumer income, the analysis can be used to indicate the most likely level of price for some period in the future. Likewise, it can be used to indicate the probable effect of changes in supply or in income on price. Such an analysis will be useful in appraising the probable effects of an increase in the yield of cottonseed oil on prices of cottonseed oil and related fats and oils.

Factors That Affect the Average Price for the Group

Figure 4 shows the results of an analysis of the factors that affect prices of food fats and oils other than butter and lard. The following three variables were used in explaining annual variations in this price index: (1) Per capita supply of fats and oils used in food products (other than butter and lard) in pounds; (2) per capita supply of lard in pounds, and (3) personal disposable income per capita in dollars. Because of technical reasons discussed in Appendix notes 2 and 5, all of the variables were expressed in logarithms. This accounts for the curvilinear nature of the average relationships shown on the chart when all variables are expressed in their original terms. The analysis was based on the calendar years 1922–42 and 1947–51. During the omitted years, price ceilings were in effect. The three variables together accounted for 92 percent of the variation in prices of edible fats and oils during this period. The variables used, together with the actual and computed prices and certain related statistical measurements, are shown in Appendix note 5. Certain alternative analyses also are discussed in note 5.

The uppermost section of the chart shows the relationship between price and supply of fats and oils used in food (excluding butter and lard) after allowing for the effects of the other factors included in the analysis. Years included in the analysis are indicated by dots; years excluded are indicated by x's. On the average, a 1-percent change in this supply variable was associated with a change of 1.6 percent in the opposite direction in price. As prices are more variable than supply, the demand for edible fats and oils at the wholesale level is said to be "inelastic." This has been generally recognized by other research workers and the fats and oils trade. Some of the factors that would be expected to cause this are discussed in Appendix note 5.

The second section of the chart shows the relationship between the price of edible fats and oils, excluding butter and lard, and the supply of lard after allowing for the effects of the other factors included in the analysis. On the average, a 1-percent change in the supply of lard was associated with a 1.1-percent change in the opposite direction in prices of edible fats and oils. Thus, a 1-percent change in the supply of lard had about two-thirds as much effect on the price of edible fats and oils, excluding butter and lard, as did a 1-percent change in the supply of these oils. For the years included in the analysis, the supply of lard was about three-fourths as large as the supply of other fats and oils (excluding butter) used in food. Thus, a 1-pound change in the per capita supply of lard would be expected to have about as much

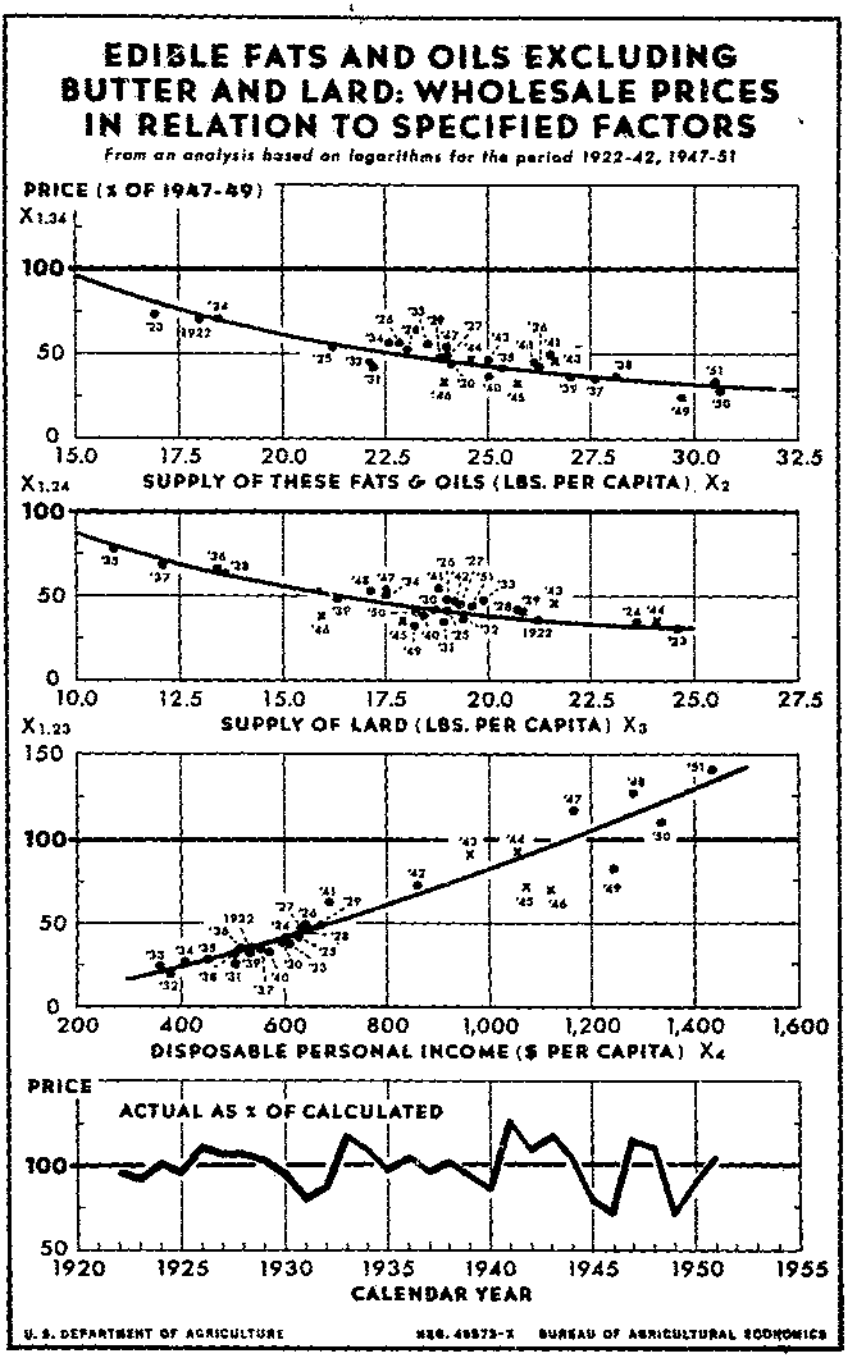

FIGURE 4.—The three factors—supply of fats and oils used in food (excluding butter and lard), supply of lard, and disposable income—accounted for 92 percent of the variation in prices of edible fats and oils, excluding butter and lard, during 1922–42 and 1947–51.

effect on the price of edible fats and oils, excluding butter and lard, as does an 0.9 pound change in the supply of these oils.

The third section of the chart shows the relationship between price and disposable income after allowing for the effects of the other factors included in the analysis. On the average, a 1-percent change in per capita disposable income was associated with a change of 1.4 percent in the same direction in price.

In the fourth section of the chart are shown the residuals (that is, the percentage the actual price is of the calculated price) plotted against time. These residuals did not follow a time trend, which would have indicated that one or more factors were causing the demand for these fats and oils to shift gradually over time. However, the residuals apparently follow a pattern that is related to changes in prices of fats and oils or to changes in the general wholesale level of prices. Such data as are available indicate that when prices rise, manufacturers and dealers tend to build up their stocks of fat and oil products, so that the demand at the wholesale level is greater than that represented by direct movement into consumption. If such stocks have accumulated, a reverse effect takes place when prices decline. Manufacturers and dealers tend to reduce their stocks, so that demand at the wholesale level is less than that represented by direct consumption. Of the variation in prices unexplained by the three independent variables included in the analysis, 38 percent was explained by year-to-year changes in these prices. Further details of this aspect of the analysis are given in Appendix note 5.

Table 8 indicates the net effect of each of these factors separately on the price of edible fats and oils, excluding butter and lard. The ratio of each independent variable to its average for the years included in the analysis is shown over a considerable range, together with the related change in price. If the effect of changes in several variables at a time is desired, this can be obtained by multiplying together the indicated ratio for each item.

For example, suppose the supply of fats and oils used in food increased by 30 percent above the average supply, the supply of lard increased by 10 percent, and disposable income increased by 50 percent above its average. As indicated in the table, prices of edible fats and oils would increase by 3 percent above the average of the years included in the analysis. This result is obtained as follows: A ratio of supply of fats and oils used in food of 1.30 is associated with a ratio for price of 0.66. A 1.10 ratio for supply of lard is associated with a ratio for price of 0.90. A 1.50 ratio for income is associated with a ratio for price of 1.74. Multiplying the three ratios for price together gives a ratio of 1.03. This is equivalent to an increase of 3 percent in the price of edible fats and oils. For the years included in the analysis the index of prices of edible fats and oils averaged 50 percent of the 1947–49 average. Thus, under the circumstances outlined here, the index would be 1.03×50, or 51.5.

The actual level of prices in terms of index numbers that would be associated with given levels of the three independent variables is shown in table 9. Expected prices for levels not shown directly in this table can be obtained by interpolation. There is a 65- to 70-percent chance that estimates derived from these tables will differ from actual prices by not more than about 15 percent, and a 95-percent chance that they

will differ by not more than 30 percent. More exact values are given in Appendix table 19.

Table 9 can be used to ascertain the expected effect on price of a change in any one of the factors when the other factors used in the analysis are at given levels. For example, the first line in the table indicates the price associated with specified levels of the per capita supply of lard when the per capita supply of fats and oils used in food products is at 15 pounds and disposable income per capita equals $500. Based on these data, an *increase* in the supply of lard from 10 to 15 pounds normally would be associated with a *decrease* from 129 to 82 in the index of wholesale prices of edible fats and oils, excluding butter and lard.

TABLE 8.—*Edible fats and oils, excluding butter and lard: Wholesale price as a ratio to the price expected under specified circumstances in relation to given levels for supply of fats and oils used in food products, supply of lard, and disposable income*[1]

Ratio to average	Per capita			Ratio of estimated price to price expected with an average—		
	Supply of		Disposable income	Supply of		Income
	Fats and oils used in food products[2]	Lard		Fats and oils	Lard	
Ratio	*Pounds*	*Pounds*	*Dollars*	*Ratio*	*Ratio*	*Ratio*
0. 50	----------	9. 0	326	----------	2. 16	0. 39
. 60	----------	10. 8	391	----------	1. 76	. 50
. 70	16. 9	12. 6	456	1. 75	1. 49	. 61
. 80	19. 4	14. 4	522	1. 42	1. 28	. 74
. 90	21. 8	16. 2	587	1. 18	1. 12	. 87
1. 00	24. 2	18. 0	652	1. 00	1. 00	1. 00
1. 10	26. 6	19. 8	717	. 86	. 90	1. 14
1. 20	29. 0	21. 6	782	. 75	. 82	1. 28
1. 30	31. 5	23. 4	848	. 66	. 75	1. 43
1. 40	33. 9	25. 2	913	. 59	. 69	1. 58
1. 50	36. 3	27. 0	978	. 53	. 64	1. 74
1. 60	----------	----------	1, 043	----------	----------	1. 90
1. 70	----------	----------	1, 108	----------	----------	2. 06
1. 80	----------	----------	1, 174	----------	----------	2. 23
1. 90	----------	----------	1, 239	----------	----------	2. 41
2. 00	----------	----------	1, 304	----------	----------	2. 58
2. 10	----------	----------	1, 369	----------	----------	2. 76
2. 20	----------	----------	1, 434	----------	----------	2. 94
2. 30	----------	----------	1, 500	----------	----------	3. 13
2. 40	----------	----------	1, 565	----------	----------	3. 31

[1] When the other independent variables in the analysis remain at their average level. From an analysis based on logarithms for the years 1922–42 and 1947–51. See Appendix note 5.

[2] Excluding butter and lard. See table 2 for items included in this variable.

The last line of the second section of table 9 indicates the price associated with specified levels of the supply of lard when the supply of fats and oils used in food products is at 40 pounds and per capita disposable income equals $1,000. Under these circumstances, an increase in the supply of lard from 10 to 15 pounds per capita normally would be associated with a decrease from 71 to 45 in the price index.

TABLE 9.—*Edible fats and oils, excluding butter and lard: Index numbers of wholesale prices with given levels of related factors*[1]

[1947–49=100]

Supply of fats and oils used in food products per capita[2]	Per capita supply of lard, pounds				
	10	15	20	25	30
	Disposable income per capita, 500 dollars				
Pounds					
15	129	82	60	46	38
20	82	52	38	30	24
25	58	37	27	21	17
30	43	28	20	16	13
35	34	22	16	12	10
40	28	18	13	10	8
	Disposable income per capita, 1,000 dollars				
15	332	212	154	120	98
20	211	135	98	76	62
25	149	95	69	54	44
30	112	71	52	40	33
35	88	56	41	32	26
40	71	45	33	26	21
	Disposable income per capita, 1,500 dollars				
15	578	369	268	209	171
20	368	235	170	133	109
25	259	165	120	94	77
30	195	124	90	70	57
35	153	97	71	55	45
40	124	79	57	45	37
	Disposable income per capita, 2,000 dollars				
15	857	547	397	310	253
20	545	348	253	197	161
25	384	245	178	139	113
30	289	184	134	104	85
35	226	144	105	82	67
40	184	117	85	66	54

[1] From an analysis based on logarithms for the years 1922–42 and 1947–51. See Appendix note 5.

[2] Excluding butter and lard. See table 2 for items included in this variable.

Expected effects on price of changes in the per capita supply of fats and oils used in food products can be observed by using any given column for the supply of lard within any one of the four sections relating to different levels of disposable income. For example, with a supply of lard at 20 pounds per capita and a per capita disposable

income of $1,000, an increase in the supply of fats and oils used in food products from 15 to 20 pounds normally would be associated with a decrease in the price index from 154 to 98.

Effects of changes in income on the index of prices can be studied by comparing the figure for any given row and column in one section with the figure for the same row and column in another section. For example, with a supply of lard at 20 pounds per capita and a supply of fats and oils used in food products at 15 pounds, an increase in per capita income from $500 to $1,000 normally would be associated with an increase in the price index from 60 to 154. Expected effects for other combinations of changes and levels for the causal variables can be found directly from the table or by interpolation.

Relation of Prices of Cottonseed Oil to the Group Average

As later sections of this bulletin emphasize cottonseed oil, an analysis was made to determine the average relationship between the prices of cottonseed oil and the prices of all edible fats and oils, excluding butter and lard. As was done in the preceding analysis, all variables were expressed as logarithms. This analysis indicated that more than 99 percent of the variation in prices of cottonseed oil was associated with changes in prices of all edible fats and oils, excluding butter and lard, and that a 1-percent change in the over-all index was associated on the average with a change of 1.1 percent in the price of cottonseed oil. The analysis was based on the same period as the preceding analysis. An analysis also was made in which the general level of wholesale prices was used as a third variable. Results were essentially the same as for the two-variable analysis. These analyses are discussed in Appendix note 6.

ADDITIONAL ANALYSES NEEDED TO MEASURE EFFECTS OF INCREASED YIELDS OF COTTONSEED OIL ON PRICES AND GROSS RETURNS

Many factors may cause production of cottonseed oil to increase or to decrease. Changes in acreage planted to cotton, in yield of cottonseed, in quantity of cottonseed used as feed or fertilizer or for planting the following crop, in the oil content of the seed, or in the method of processing the seed for oil and meal would affect production of cottonseed oil. Relationships given in this report were developed particularly for use in measuring probable effects of the adoption of processing methods for oilseeds which result in increased yields of oil on gross returns to the cottonseed-crushing industry and to growers of cottonseed and other oil-bearing materials. Adoption of these methods would not affect production of cottonseed meal, as this yield is regulated by mixing in additional quantities of hulls. Expected effects of adoption of these processing methods are to be discussed in a later report to be issued by the Production and Marketing Administration. In this section, methods by which the effects can be estimated are outlined. This general approach can be used also in studying related problems that deal with the expected economic effects of an increase in the yield of cottonseed oil because of other elements.

Products Obtained From Processing Cottonseed[14]

Major products obtained from crushing cottonseed are oil, meal, linters, and hulls. In addition, minor products—motes, grabbots, flues, and sometimes hull fibers and hull bran—result.

The yield from processing a ton of cottonseed, in quantitative terms, is the largest of all the major products obtained, and the yield of hulls is second.[15] A considerably smaller quantity of oil is obtained, and only a small quantity of linters. But the value of the oil obtained far exceeds the value of any of the other products, and the value of meal produced is second. The value of linters is considerably lower than that of either oil or meal, and the value of hulls is lowest of any of the four major products (table 10).

The purposes for which cottonseed oil is used were discussed in earlier sections.

The pressed cakes, from which the meal is obtained, are sold in one of five major forms—slab cake, cracked cake, bulk meal, bagged meal, and pellet meal. Slab cake is sold only to feed dealers or large feeders for further processing. Ground hulls are added to the meal to regulate its protein content, so that a reduction in oil content does not affect the total quantity of meal available for sale. Most of the cake and meal is used as a high-protein feed for livestock, although in some years, small quantities are used for fertilizer.

After the linters are cleaned, they are baled and sold on the basis of length of staple and other factors of quality to producers of mattresses, felted products, photographic film, guncotton, paper, cellulose, and other products. Linters are considered one of the best sources of raw cellulose. The rayon industry is a major user of the shorter-staple linters.

Factors That Affect Yields of Oil.—Yield of cottonseed oil per ton of crushings has trended slightly upward since 1909. From 1909 to 1926, the yield averaged 304 pounds, fluctuating between 291 and 322 pounds. From 1927 to 1951, the yield averaged 314 pounds, ranging from a low of 303 to a high of 324 pounds. At least part of the gradual increase is the result of increased use of improved methods of processing the seed.

The hydraulic press method of processing cottonseed has been used since the eighteenth century. It is still the principal method used in areas east of the Delta, where production of cotton is declining. The equipment used is rugged, has a long life, and permits the use of semi-skilled or unskilled labor. The screw-press method was perfected after World War I; it is used to process a variety of oilseeds. The outturn of oil is considerably higher by this method than by the hydraulic process. Screw presses predominate in the cotton areas of Oklahoma and Texas which were developed after World War I. The solvent method of extracting oil from cottonseed was perfected after 1947. Higher yields of oil are obtained by this process, but the plant is more expensive to install. A relatively large volume is needed for efficient operation and also more highly skilled labor.

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[14] Discussion of stages in cottonseed processing are given in Bailey (*2*, chs. 14 and 15) and Jamieson (*5*, pp. 199-205).

[15] The yield of hulls does not include the quantity of hulls mixed with the meal to regulate the protein content.

TABLE 10.—*Cottonseed, major products: Yields and values, averages, 1932–46, annual 1947–51*

Year beginning August	Yield per ton of cottonseed processed [1]				Price per pound [2]			
	Oil	Meal	Linters [1]	Hulls	Oil	Meal	Linters	Hulls
Average:	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Cents*	*Cents*	*Cents*	*Cents*
1932–36	309	908	127	528	6.8	1.3	3.4	0.33
1937–41	316	894	157	508	7.4	1.4	3.0	.37
1942–46	312	899	182	473	15.2	2.6	5.4	.62
1947	312	930	186	452	26.3	4.3	6.7	.78
1948	320	897	183	463	15.4	3.2	3.9	.33
1949	323	895	176	469	12.5	3.2	5.6	.35
1950	321	896	185	461	20.4	3.9	16.2	.90
1951	319	930	160	451	13.0	4.2	8.7	.87

	Value of yield							
	Total				Percentage distribution			
	Oil	Meal	Linters	Hulls	Oil	Meal [3]	Linters	Hulls [3]
Average:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Percent*	*Percent*	*Percent*	*Percent*
1932–36	21.01	11.80	4.32	1.74	54.0	30.4	11.1	4.5
1937–41	23.38	12.52	4.71	1.88	55.0	29.5	11.1	4.4
1942–46	47.42	23.37	9.83	2.93	56.7	28.0	11.8	3.5
1947	82.06	39.99	12.46	3.53	59.4	29.0	9.0	2.6
1948	49.28	28.70	7.14	1.53	56.9	33.1	8.2	1.8
1949	40.38	28.64	9.86	1.64	50.1	35.6	12.2	2.1
1950	65.48	34.94	29.97	4.15	48.6	26.0	22.3	3.1
1951	41.41	38.97	13.86	3.92	42.2	39.7	14.1	4.0

[1] Computed from production reported in terms of "equivalent 500-pound bales on basis of net weight."

[2] Cottonseed oil: crude, tanks, f. o. b. Southeastern mills; cottonseed meal: 41-percent protein, bagged, Memphis; cottonseed linters: weighted average value per pound for all grades and market points, f. o. b. mill; cottonseed hulls: average value per pound, 1932–44, computed on the basis of data on total production and total value, 1945–46, f. o. b. mills throughout territory, 1947–51, carload lots, Atlanta.

[3] These percentages have a slight upward bias because of the quotations used.

Compiled from reports of the Bureau of the Census, the Production and Marketing Administration, the Oil, Paint, and Drug Reporter (*9*) and the New York Journal of Commerce (*8*).

In the newer cotton-producing sections of Texas and the far West, the solvent method is gradually replacing the older methods. These areas have sufficient supplies of cottonseed and adequate rural highways to permit easy transport of the raw material to keep the large plants operating more than 300 days a year. It is estimated that around 7 to 8 percent of the 1950–51 crop of cottonseed was processed by solvent methods in five plants, and that around 20 to 30 percent was produced by the screw-press method.[18]

The constituents that determine official United States grades of cottonseed are oil, protein or ammonia, moisture, free fatty acids, and foreign matter. Data on the average qualities of cottonseed, as

[18] The above material was taken from Technology in Food Marketing (*16*, p. 77).

determined by chemical measurements of these constituents in sample quantities of seed, are available starting with the crop year 1944–45. These are shown in table 11.

Table 11.—Cottonseed: Factors measuring quality and yield of oil, meal, and hulls, 1944–50

Year beginning August	Factors measuring cottonseed quality					Yield per ton of cottonseed crushed		
	Oil content	Ammonia content	Moisture content	Free fatty acid content	Foreign matter	Oil	Meal	Hulls
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*	*Pounds*	*Pounds*
1944	18. 5	3. 88	11. 2	1. 4	0. 8	311	919	463
1945	18. 0	3. 62	12. 2	2. 6	1. 1	312	879	480
1946	18. 7	3. 61	12. 4	1. 0	. 8	315	882	471
1947	18. 3	3. 88	11. 3	1. 4	. 8	312	930	452
1948	18. 7	3. 72	11. 3	1. 4	. 9	320	897	463
1949	19. 1	3. 68	11. 6	1. 9	1. 1	323	895	469
1950	18. 7	3. 64	12. 8	1. 9	1. 1	321	896	461

Compiled from reports of the Production and Marketing Administration and the Bureau of the Census.

The principal factor that determines the yield of crude oil from processing a ton of cottonseed is the oil content of the seed. Ammonia content is secondary. The greater the ammonia content, the larger is the production of meal and therefore the greater is the quantity of oil that remains in the meal. An additional influence is the amount of linters left on the seed. Normally, the greatest absorption of oil by the linters occurs during hulling, which comes after delinting. A fourth factor that affects the yield of oil is the moisture content of the decorticated cottonseeds at time of crushing. The higher the moisture content, up to a certain point, the higher is the yield of oil.

The amount of free fatty acids in the oil indicates the extent to which the oil has deteriorated; in other words, it is a measure of the quality of the oil. However, the higher the free fatty acid content, the lower is the yield of *refined* oil from a given quantity of crude oil.

A statistical analysis, for the crop years 1921–40, was run to ascertain whether the effect of fluctuations in the price of cottonseed oil on the yield of oil per ton of cottonseed processed could be measured.[17] Many mills operate their presses on a fixed schedule without regard to the relative value of the oil obtained and the labor and other costs involved in obtaining it. Some operators, on the other hand, are price conscious and when prices of oil are relatively high, they use a longer press cycle. Results from this analysis indicate that the effects on the quantity of cottonseed oil obtained per ton of seed processed as a result of changes in the price of the oil and in the quantity of seed processed are not measurable. These results probably reflect partly the fact that the importance of these factors is small and partly the fact that such important variables as quality of the seed and type of processing equipment on hand could not be included in the analysis because of lack of data.

[17] See Appendix note 7.

FACTORS THAT AFFECT THE YIELD OF CAKE AND MEAL.—The yield of cake and meal per ton of cottonseed processed is determined by the ammonia content of the seed. Meal is usually marketed by each mill with a fixed protein content: 36 to 41 percent in the Southeast, about 41 percent in the South Central region, and 41 to 43 percent in the Southwest. Protein content is measured in terms of ammonia. To regulate its protein content, the meal is filled with ground hulls. Consequently, the higher the ammonia content of the seed, the greater is the quantity of hulls necessary to reduce the meal to the standard percentage of protein and, therefore, the greater the yield of cake and meal. The ammonia content of the seed appears to rise with increases in the amount of sunshine during the growing season.

Yields of cake and meal from processing a ton of cottonseed are not appreciably affected by the quantity of oil recovered from the seed. Any increase in the quantity of oil obtained per ton of cottonseed processed is compensated for by mixing an additional quantity of the less expensive hulls with the meal, to maintain a given percentage of protein. As hulls contain a minor amount of protein, each pound of additional oil recovered per ton of seed processed would require the addition of fractionally more than a pound of hulls. This would tend to increase the yield of cake and meal as recovery of oil becomes more efficient. However, this increase is not appreciable.

A statistical analysis, for the crop years 1921–40, indicates that changes in the price of cottonseed meal have no statistically measurable effect on the yield of cake and meal.[18] As meal is the second most valuable product of cottonseed crushing, this is a reasonable finding. After producing all the oil possible, it is to the interest of crushers to produce as much meal as possible. The analysis also indicates that changes in the quantity of cottonseed crushed are not associated with fluctuations in the yields of cake and meal.

RELATIONSHIPS INVOLVED IN MEASURING EFFECTS OF INCREASED YIELDS OF COTTONSEED OIL ON PRICES, TOTAL RETURNS, AND OTHER FACTORS

Figure 5 presents a simplified diagram of the economic factors that would be affected by a change in the yield of cottonseed oil per ton of seed processed. The effects of an increase in yield of oil may be considered, in a general way, to be two-pronged. One prong operates through the effect on the supply of cottonseed oil; the other, through the effect on the value of the yield of oil. A third prong indicated on the chart relates to the effect on the yield of cottonseed hulls per ton of seed processed. But it is not necessary to dwell upon this aspect at any length. The value of the hulls accounted for only 4 percent of the total value of cottonseed products in 1937–41 and only 2 percent in 1947–50.

Changing the composition of cottonseed meal by removing most of the residual oil and mixing in additional quantities of hulls could affect its quality and its acceptability for livestock feeding. Extraction of the oil by solvent rather than mechanical means also could affect the meal to some extent. Research to date indicates that these problems are not of great importance. In many localities, meal from solvent and that from screw-press operations sell at the same price.

[18] See Appendix note 8.

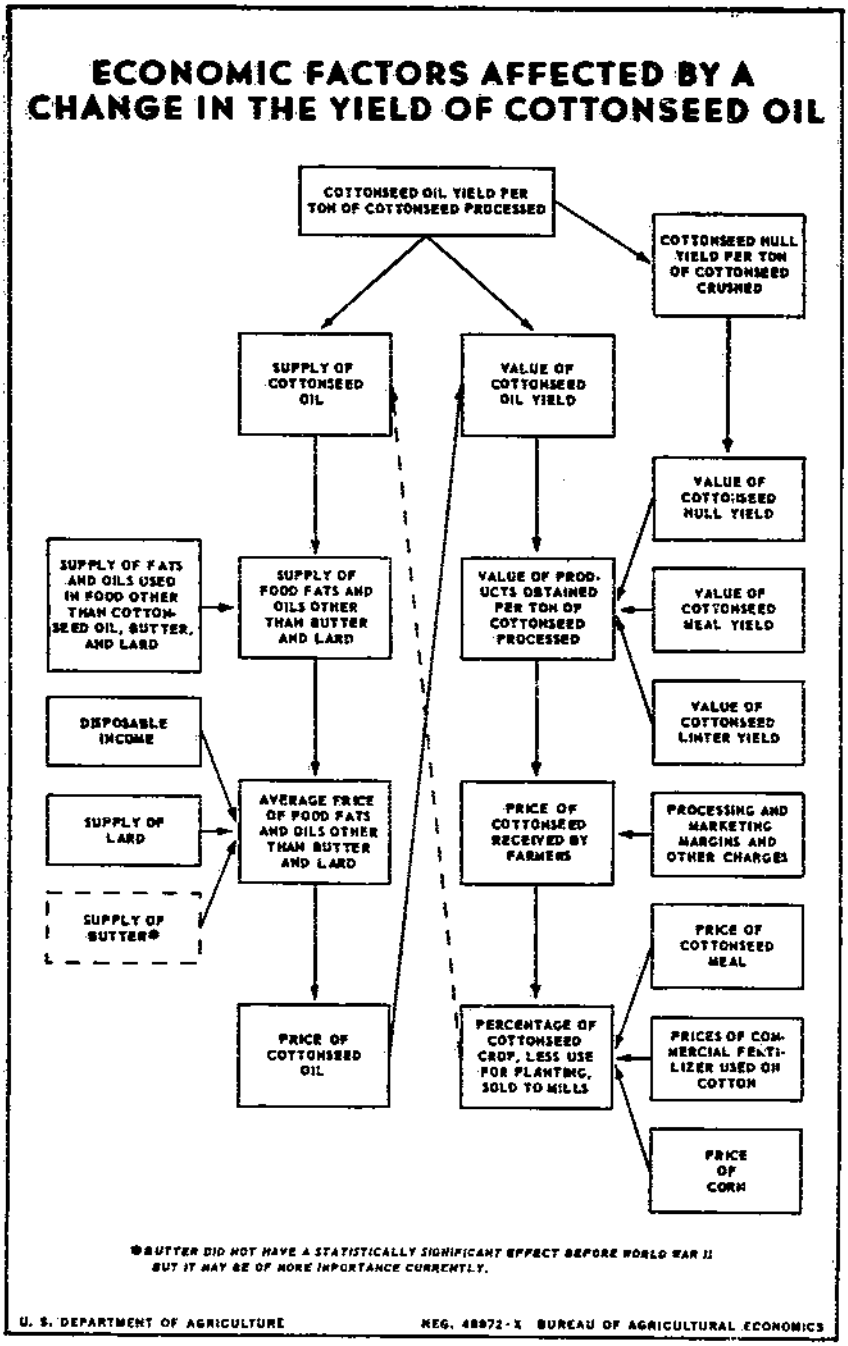

FIGURE 5.—The effects of an increase in yield of cottonseed oil per ton crushed can be considered to be two-pronged. One prong affects the supply of cottonseed oil; the other affects the value of the oil yield. The net effect on the price received by farmers for cottonseed must allow for both aspects. The several interrelationships are discussed in detail in the text.

An increase in the yield of cottonseed oil will increase its supply. As indicated by the analysis of factors that affect prices of food fats and oils, this will tend to reduce its price. However, the price-depressing effects are considerably reduced, in a sense, because a given percentage increase in production of cottonseed oil is equivalent to a much smaller percentage increase in the supply of all fats and oils, other than butter and lard, used in food. Because of the competitive nature of the demand for cottonseed oil, this total supply is the effective variable in affecting prices of cottonseed oil. Other variables shown on the chart in connection with this prong have been discussed previously.

An increase in the yield of cottonseed oil would tend to increase directly the value of the products obtained per ton of seed crushed. However, this effect would be offset, at least in part, by the lower price for cottonseed oil that would result from the increased supply. The net effect can be determined from analyses given in this bulletin. As shown in a later section, prices received by farmers for cottonseed in the past have been closely associated with the value of the products obtained per ton crushed, and this price affects somewhat the percentage of the crop, less use for planting, sold to crushing mills. This, in turn, would affect the supply of cottonseed oil. However, the analyses indicate that the secondary effects are negligible.

Use of these analyses in measuring the net effects of the several relationships on prices of cottonseed and cottonseed oil and on gross returns are discussed in more detail in a later section.

Production of cottonseed is affected only slightly by its price.[19] Since 1933, acreage has been determined mainly by the Government acreage allotment program. Yields have shown an upward trend in recent years, reflecting improved planting techniques and continued applications of soil-conserving and improvement methods. Cotton lint represents a much larger part of the total value of the cotton crop than does the seed. It can be assumed that changes in prices of cottonseed that might arise from improved methods of processing the seed would only affect negligibly the acreage planted to cotton.

Cottonseed is highly perishable. Careful prestorage handling and processing are required to prevent deterioration and financial loss. The storage function is performed almost exclusively by mills, in which adequate facilities are available, although even at mills, cottonseed is not carried beyond one season.

Increases in production of cottonseed oil would tend to reduce prices of all edible fats and oils. As most of these fats and oils are byproducts of other industries, a lowering of their price would affect their production very little. Soybeans, however, are produced mainly for their oil and meal content. In certain areas, they compete for land with corn, cotton, and other crops. Hence, a permanent lowering in the value of soybeans in comparison with the price of competing crops might result in some reduction in acreage and production of soybeans, or in a slowing up of any expansion that might otherwise occur. This would tend partly to offset the effect of the increase in the supply of cottonseed oil on prices of soybean oil, cottonseed oil, and other edible fats and oils.

[19] For a discussion and analysis of the relationship between acreage of cotton and prices of cotton and cottonseed, see Walsh (*20*).

Factors That Affect the Price Received by Farmers for Cottonseed

Prices paid to farmers for cottonseed are generally based on mill price quotations in the locality. A recent study indicated that the price paid by ginners is most frequently computed by deducting a specified margin from the mill price.[20] This margin covers various expenses and allows a profit. A second important determinant of cottonseed prices is competition among ginners for seed.

Although most of the cottonseed processed is bought by millers in the first 3 to 6 months of the crop year, the products of processing the seed generally are marketed during a longer period.[21] Mill prices for cottonseed depend to a large extent upon the anticipated yield of the products obtained by processing cottonseed and the prices at which millers expect to market these products during the marketing season. Therefore, prices paid to farmers for cottonseed reflect principally the expected value of the products of the seed. As an alternative, millers may consider current prices of futures contracts or current prices in the forward-shipment market. These in turn depend upon anticipations of the value of the products in the delivery period, so that the same economic forces are involved.

The spread between the wholesale value of cottonseed products and the price paid to farmers for cottonseed reflects various processing and marketing costs and profit margins. In addition, the spread is affected by the amount by which the expected value of cottonseed products differs from the value realized when the products are marketed.

Statistical analysis for the 1922–40 crop years shows a close relationship between changes in the season average price received by farmers for cottonseed and changes in the combined value of yields of major cottonseed products (oil, meal, hulls, and linters) per ton of seed processed.[22] According to the analysis, the season average price of cottonseed to farmers (in dollars per ton) tended to equal 74 percent of the combined wholesale value of the major cottonseed products obtained per ton of seed processed (in dollars) less $5.81. For example, the 1939–40 crop year average value of the yields of oil, meal, hulls, and linters per ton of seed processed amounted to $37.77. The estimated price obtained by this computation is nearly the same as the 1939–40 average price of $21.17 for cottonseed.

Use of this analysis in measuring the effects of increased yields of cottonseed oil on prices received by farmers for cottonseed is discussed in a later section.

Factors That Affect the Percentage of the Cottonseed Crop, Less Use for Planting, Sold to Mills

Part of the cottonseed crop is retained on the farm for use as seed, livestock feed, and fertilizer. In some years, a minor part is exported. The remainder is used for domestic processing into oil, meal, linters, hulls, and other products (table 12).

Since 1944, when data first became available, planting requirements have averaged between 27 and 32 pounds per acre in cultivation on

[20] See Whitten and Stevenson (*22*).
[21] See Kromer and Smith (*6*).
[22] See Appendix note 9.

July 1. Estimated seed requirements represented 7 to 12 percent of the crop for most years during 1909–33, and from 7 to 8 percent for most years during 1934–47. The decline in later years reflected the increase in yield of cottonseed per acre and the reduction in acreage during this period. The quantity of seed used for planting declined to from 6 to 7 percent of the crop during the 1948 to 1950 seasons, as a result of high cottonseed yields and the use of improved planting techniques. These techniques tend to reduce the number of pounds of seed planted per acre, as seeds are planted less densely and are delinted before planting. When acreages shift sharply, as they have done in recent years, seed requirements as a percentage of the preceding crop fluctuate considerably.

Cottonseed is rich in protein because of its meal content and in fat (high in energy value) because of its oil content. To some extent, therefore, cottonseed may be substituted for cottonseed meal, a high-protein feed, and for corn, the leading source of carbohydrates (also high in energy value) used in livestock feeding on cotton farms. Heavy or prolonged feeding of cottonseed to livestock is not practicable, however, as the free gossypol content of the seed has a toxic effect.

TABLE 12.—*Cottonseed: Production and disposition, averages 1921–50*

Year beginning August	Production [1]	Used on farms			Production less quantity used for planting	Sales to oil mills [5]	Percentage of production less quantity used for seed	
		For planting [2]		For feed and fertilizer [4]			Sold to oil mills	Used for feed and fertilizer
		Total	Per acre [3]					
Average:	*1,000 tons*	*1,000 tons*	*Pounds*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*Percent*	*Percent*
1921–30	5,806	633	-------	649	5,173	4,524	87.5	12.5
1931–40	5,595	461	-------	589	5,134	4,545	88.5	11.5
1941–47	4,458	318	-------	265	4,140	3,875	93.6	6.4
1948–50	5,536	361	29	269	5,175	4,906	94.8	5.2

[1] Before 1928 production of cottonseed was computed on the basis of 65 pounds of seed to 35 pounds of lint.
[2] Used for planting crop of succeeding year.
[3] Before 1943, seed used for planting was computed at a constant rate for each State. The United States average ranged between 31 and 32 pounds per acre in cultivation July 1.
[4] Residual. Includes small quantities exported in some years.
[5] Cash sales plus exchanges for meal.

Bureau of Agricultural Economics.

The usefulness of cottonseed as a fertilizer results from its meal content. Until about 1940, cottonseed meal had been an important fertilizer, especially on cotton farms. In addition, commercial fertilizer contained a small proportion of cottonseed meal. From the beginning of World War II, the high price of cottonseed meal has almost eliminated its direct use for soil fertilization and as an ingredient in the manufacture of commercial fertilizer.

During the period 1909–33 an average of 13 percent of the cottonseed crop, after allowing for planting requirements, was retained on

farms for use as feed and fertilizer; the remainder was sold for processing or export. In most years, exports amounted to less than 5,000 tons. Since 1933, the percentage retained on farms for uses other than planting has shown a downward trend. This percentage averaged about 12 percent in 1931–40 and 6 percent in 1941–49.

Statistical analysis for the crop years 1922–40 indicates that about 40 percent of the changes in percentage of the cottonseed crop sold to mills, after allowing for planting use, were associated with changes in the price of cottonseed received by farmers and with changes in the index of prices paid by farmers, including commodities, interest, taxes, and wage rates.[23] On the average, a change of 1 percent from the preceding year in the price of cottonseed was associated with a change in the same direction from the preceding year of 0.1 percent in the quantity of seed sold to mills. A change of 1 percent from the preceding year in the index of prices paid by farmers was associated, on the average, with a change in the opposite direction of 0.4 percent in the quantity of seed sold to mills.

Table 13 indicates the net effect of each of the factors discussed separately on the percentage of the cottonseed crop sold to mills. The ratio of each variable to the preceding year is shown over a considerable range, together with the related change in the percentage of the crop sold. The effect of changes in both variables if desired can be obtained by multiplying together the indicated ratio for each item. For example, during 1947 to 1949, 94.3 percent of the cottonseed, less use for planting, was sold to mills. The average price of cottonseed received by farmers in these years was $65.50 a ton and the index of prices paid by farmers (1910–14=100) was 253. Suppose that the price of cottonseed increased by 5 percent and that the index of prices paid increased by 10 percent. As indicated by the table, the percentage of the cottonseed crop, after deduction of the quantity used for planting, sold to mills would have declined by 3.0 percent

This result is obtained as follows: A ratio of cottonseed prices in the current year to that of the preceding year of 1.05 is associated with a ratio of 1.004 for percentage of the crop sold. A ratio of the index of prices paid in the current year to that of the preceding year of 1.10 is associated with a ratio of 0.966 for percentage of the crop sold. Multiplying these two ratios together gives a ratio of 0.970. Thus, the actual percentage sold would equal 91.5 percent (94.3 times 0.970). Results for other combinations of these two factors can be determined from the table, either directly or by interpolation.

Changes in the percentage of cottonseed sold to mills probably are more directly affected by changes in the price of cottonseed meal paid by farmers in the cotton States, the price of corn, the price of commercial fertilizer used on cotton, and the availability of commercially mixed livestock feeds than by the index of prices paid by farmers for all commodities. However, the separate effects of these changes cannot be measured statistically. This may be due chiefly to the following circumstance: The meal, corn, and fertilizer price series tend to fluctuate in almost the same way as does the price of cottonseed received by farmers. The effect of changes in the price of cottonseed on the percentage of the crop sold to mills is evidently greater than the effects of changes in the prices of these items. Consequently, the

[23] See Appendix note 10.

effect of changes in the price of cottonseed is statistically measurable, but the effect of changes in the other prices cannot be separated out. Another possible reason is that the effect of changes in these items on the percentage of the crop sold to mills is too small to be statistically measurable after allowing for errors in the data.

TABLE 13.—*Cottonseed crop, less use for planting: Relation between year-to-year changes in percentage sold to mills and price received by farmers for cottonseed and the index of prices paid by farmers, including interest, taxes, and wage rates* [1]

Ratio to preceding year			
Estimated percentage of crop sold	Cottonseed price	Estimated percentage of crop sold	Prices paid
0. 975	0. 75	1. 115	0. 75
. 980	. 80	1. 088	. 80
. 985	. 85	1. 064	. 85
. 990	. 90	1. 041	. 90
. 995	. 95	1. 019	. 95
1. 000	1. 00	1. 000	1. 00
1. 004	1. 05	. 982	1. 05
1. 009	1. 10	. 966	1. 10
1. 012	1. 15	. 948	1. 15
1. 016	1. 20	. 934	1. 20
1. 020	1. 25	. 919	1. 25

[1] When the other independent variables in the analysis remain at the previous year's level. Based on the multiple regression analysis discussed in this section. See Appendix note 10.

USE OF THESE ANALYSES IN MEASURING NET EFFECTS OF INCREASED YIELDS OF COTTONSEED OIL ON PRICES AND TOTAL RETURNS FOR COTTONSEED

Material presented in earlier sections has shown how increases in the yield of cottonseed oil would affect various related market factors. Three sets of relationships were presented which account for the major market forces that would be affected. The analyses are designated as relationships I, II, and III.

Relationship I estimates the effect on the wholesale price of edible fats and oils (excluding butter and lard) of changes in the following three factors: Per capita supply of fats and oils used in food products other than butter and lard, per capita supply of lard, and per capita disposable income. A separate equation is used to translate this into the associated change in the price of cottonseed oil.

Relationship II estimates the effect of changes in the value of the major cottonseed products obtained per ton of seed processed on the season average price of cottonseed paid to growers. These products are oil, meal, hulls, and linters.

Relationship III estimates the effect of changes in the following two factors on the percentage of the cottonseed crop, less use for planting, sold to mills: Season average price of cottonseed received by growers and index of prices paid by farmers, including commodities, interest, taxes, and wage rates.

The statistical analyses discussed in Appendix notes 5, 6, 9, and 10 yield the following equations for these three relationships. In each equation the independent variables that would be directly affected by a change in the yield of cottonseed oil are underlined.

Relationship I:

X_1'—Price of cottonseed oil per pound, crude, tanks, f. o. b. Southeastern mills (cents)
X_1—Wholesale price of edible fats and oils, excluding butter and lard, at leading markets, index numbers (1947–49=100)
X_2—Supply of fats and oils used in food products, excluding butter and lard, per capita (pounds). The separate items used in computing this variable are shown in table 2.
X_3—Supply of lard per capita (pounds).
X_4—Personal disposable income per capita (dollars).

When all variables are expressed in logarithms, the following equations apply:

$X_1 = 1.37 - 1.57 \underline{X_2} - 1.11 X_3 + 1.37 X_4$

$X_1' = -.94 + 1.14 \underline{X_1}$

Use of table 9 will yield results nearly comparable to those obtained from the first equation.

Relationship II:

X_1—Season average price per ton received by farmers for cottonseed (dollars)
X_2—Combined wholesale value of the major cottonseed products obtained per ton of seed processed (dollars). The separate items used in computing this variable are shown in Appendix table 25.

$X_1 = -5.81 + .74 \underline{X_2}$.

This equation is in terms of actual data rather than logarithms.

Relationship III:

X_1—Percentage of the cottonseed crop, less use for planting, sold to mills, year beginning August (percent)
X_2—Season average price per ton received by farmers for cottonseed (dollars)
X_3—Index of prices paid by farmers, including commodities, interest, taxes, and wage rates, year beginning August (1910–14=100)

When all variables are expressed in logarithms of link relatives, the following equation applies:

$X_1 = 2.56 + .095 \underline{X_2} - .38 X_3$.

Use of table 13 will yield comparable results.

These equations are of necessity based on historical data; they will apply in future only if the general structure of the industry remains unchanged. The four equations apparently applied reasonably well through the 1951–52 crop year. However, it is possible, particularly with respect to relationship II, that they may not apply in future. Recent developments in the marketing and processing of soybeans discussed in Simon (*12*) have tended to increase soybean prices relative to the combined value of the products obtained from processing a bushel of soybeans. At the time this report went to press, the Production and Marketing Administration was preparing a report concerning possible economic effects of the adoption of types of cottonseed crushing plants that will be most feasible if new plants are built. Should it appear likely that the changes indicated would significantly affect the average cost of crushing a ton of seed or the competitive nature of the cottonseed-crushing industry, then the equation developed under relationship II might no longer apply and some sort of accounting relationship would be required to indicate the probable effects of the adoption of such plants on returns to cotton growers.

In using these equations to estimate the probable effect of an increase in yield of cottonseed oil on returns to processors and growers or for other similar purposes, some level must be specified for the variables not directly affected by the change. Net effects on the price of cottonseed oil and on total returns to processors and growers will depend upon the level used for the other variables. Thus for any specific use of these equations, such values should be placed at levels which appear most likely to apply.

All of these equations are based on statistical analyses and are subject to certain types of statistical errors. The magnitude of these are indicated in the Appendix.

A detailed example of the use of these equations is given in Appendix note 11.

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APPENDIX

NOTE 1. DOUBLE DEMAND CURVES FOR A SINGLE COMMODITY

The double demand concept for cottonseed oil and its application to price relationships among food fats and oils was developed in the main body of the bulletin. The concept of double demands is discussed in this note in the technical terminology of supply and demand curves in order to display the fundamental relationships involved.

Five sets of supply and demand curves supporting the presentation are shown in figure 6. Sets 1 and 2 present two demand schedules for cottonseed oil, D_1 and D_2, and two supply schedules, S_1 and S_1'. Sets 4 and 5 present two demand schedules for food fats and oils other than cottonseed oil, butter, and lard, D_3 and D_4, and two supply schedules, S_2 and S_2'. Set 3 presents a demand schedule, D, and a supply schedule, S, for food fats and oils including cottonseed oil but excluding butter and lard.

In set 1, D_1 represents the noncompetitive demand schedule for cottonseed oil for use in food products. In the minds of manufacturers of margarine, shortening, and other food fat and oil products, there are no substitutes for this segment of demand for cottonseed oil. This nonsubstitutable demand for cottonseed oil (schedule D_1) is derived from the demand for these products.

The cottonseed-oil supply curve, S_1 in set 1, represents the total supply of cottonseed oil offered for sale to the users (manufacturers of edible fat and oil products) in a given crop year. This schedule has been assumed to be perfectly inelastic. This is approximately true and adequate for the purposes at hand.

Set 2 presents the schedules D_2 and S_1'. The competitive demand for cottonseed oil for use in food products is represented by D_2. This is the demand for which cottonseed oil and other food fats and oils

(excluding butter and lard) are, for all practical purposes, identical commodities. As there exist perfect substitutes that can satisfy this demand for cottonseed oil, D_2 is perfectly elastic.

The supply curve S_1' represents the "excess supply" of cottonseed oil that remains after the noncompetitive demand for this oil has been satisfied. This supply is equal to S_1 minus D_1. For example, in set 1, the total supply is equal to PB, the noncompetitive demand will take PA of this supply at price P, leaving the balance (AB) for the competitive segment of cottonseed oil demand. Therefore, AB in set 1 is equal to PC in set 2.

In set 5, D_3 represents the noncompetitive demand schedule for food fats and oils other than cottonseed oil, butter, and lard for use

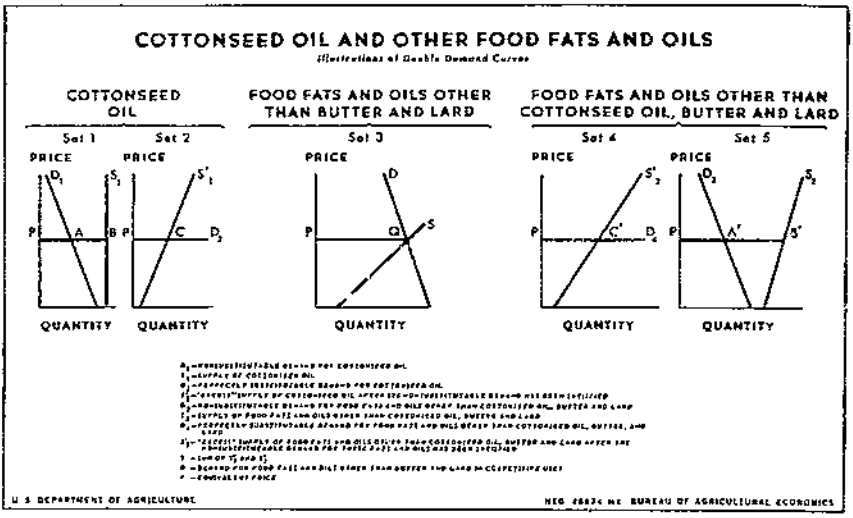

FIGURE 6.—The theory of double demand curves for a single commodity demonstrates that an analysis of the effect on the price of cottonseed oil of an increase in its supply only can be studied through the price-supply relationship for all food fats and oils, other than butter and lard, taken as a group.

in food products. For purposes of this discussion, it is sufficient to assume that such a demand for this group of food fats and oils does exist. This is probably true. Nevertheless, the existence of such a demand is not necessary to support the logic of this discussion. It is shown in set 5 as a matter of convenience. As D_3 represents the nonsubstitutable demand for this commodity group, it is likewise derived from the demand for edible fat and oil products.

The supply schedule S_2 represents the total supply of food fats and oils other than cottonseed oil, butter, and lard. The principal commodities in this group are soybean and coconut oils. Soybean oil is used in considerable quantities in nonfood products, principally in the drying-oil industries. If the price of soybean oil rises relative to the price of other drying oils, its use in drying-oil products, such as paints and varnishes, tends to decline. Thus, the supply of soybean oil available to manufacturers of food products such as margarine and shortening is not perfectly inelastic. Coconut oil is either imported or produced from imported copra, so that the domestic

supply is responsive to changes in the domestic price. Consequently, the supply curve S_2 is assumed to be less than perfectly inelastic.

The demand schedule D_4, in set 4, represents the competitive demand for food fats and oils other than cottonseed oil, butter, and lard for use in food products. As cottonseed oil is perfectly substitutable for these fats and oils in the competitive uses, the demand schedule D_4 is perfectly elastic.

The supply schedule in set 4, S_2', is the "excess supply" of food fats and oils other than cottonseed oil, butter, and lard and is equal to S_2 minus D_3. The supply schedule S_2' is similar to the supply schedule S_1' in set 2. At price P, the excess supply in set 5, $A'B'$ is equal to PC' in set 4.

Hence, cottonseed oil does not have *a* demand curve but a *pair* of demand curves. One is D_1, which may be elastic or inelastic. The other, D_2, is perfectly elastic. On the basis of the charts shown in figure 6, it is apparent that a study of the price-quantity relationship for cottonseed oil alone is logically incorrect. The quantity to be associated with price in such a study must include the supply S_2' as well as the supply of cottonseed oil. The excess supply represented by schedule S_2' is, for all practical purposes, as much a part of the supply of cottonseed oil as the excess supply represented by S_1'. If the price-quantity relationship for cottonseed oil alone were estimated, it would probably indicate a demand schedule with a slope somewhere between the slope of D_1 and D_2. Such a result has no economic meaning. As the supply represented by S_2' cannot be measured, the relationship between the price of cottonseed oil and the combined supply S_1 plus S_2' cannot be estimated statistically.

The supplies indicated by S_1' and S_2' represent practically identical commodities. Therefore, their prices will tend to be identical. However, in view of the differences in the physical and chemical characteristics of individual food fats and oils other than butter and lard, as previously discussed, it is their equivalent-prices that will tend to be equal, rather than their market prices. Hence, price P shown in figure 6 represents the equivalent-prices of cottonseed oil and other food fats and oils (excluding butter and lard). As these supplies represent identical commodities, it is logical to combine them and consider them as the supply of a single commodity. This is done in set 3 where the supply schedule S has been constructed as the sum of S_1' and S_2'. It is immaterial to the manufacturers' demands, represented by D_2 and D_4, whether they buy S_1' or S_2'. Therefore, these demands may be combined into one demand schedule (D) for commodity S. However, D_2 and D_4 are perfectly elastic because S_1' and S_2' are perfect substitutes. When the supplies are combined, the combined demand for this supply (S) is no longer perfectly elastic as the commodity represented by S no longer has perfect substitutes. The combined demand for S represents the balance of the fats and oils required for the manufacture of margarine, shortening, and other edible fat and oil products, after the nonsubstitutable demands for cottonseed oil and other food fats and oils other than butter and lard have been satisfied. Therefore, this demand is likewise derived from the demand for these products.

Hence, the three demand schedules D_1, D_2, and D are derived from the demand for edible fat and oil products. These demand curves probably differ from the demand schedule for the products because

of various manufacturing and marketing costs incurred in producing and marketing these products. It is not necessary for this discussion to determine the nature of the demand curve for the products nor to discuss its relationship to the derived demand schedule. It is sufficient to point out that there is a relationship. This relationship depends upon the marketing and pricing practices of the industry and other related factors. Further, as the demand schedules D_1, D_3, and D are similarly related to the demand schedule for edible fat and oil products, they have the same slope and are additive. Therefore, although these derived demand schedules cannot be separately determined by statistical analysis, the combined schedule (D_1+D_3+D) representing the schedule of demand for food fats and oils other than butter and lard could be statistically determined.

It is apparent from this development and from the discussion of competitive relationships among food fats and oils that a determination of the effect of an increase in the supply of cottonseed oil on its price can be arrived at only by a study of the price-supply relationship for food fats and oils other than butter and lard taken as a group.

Note 2.—Statistical Methods Used

The relationships among factors were investigated by use of the techniques of multiple correlation and regression. Logarithmic rather than arithmetic relationships were assumed in most instances.

Use of arithmetic (or actual) data implies that the relationships between X_1 and X_2 and between X_1 and X_3 are additive. That is, the effect of X_2 and X_3 upon X_1 are independent of each other, so that the combined effect of X_2 and X_3 upon X_1 is equal to the sum of the effects of X_2 ($b_{12.3}X_2$) and X_3 ($b_{13.2}X_3$): Hence, arithmetic data were used when it was thought that the net effect of each independent variable upon X_1 was independent of the effects of the other independent variables.

Use of logarithmic data implies that the relationships between X_1 and X_2 and between X_1 and X_3 are additive in terms of the logarithms. If such an equation is taken out of logarithms, the following exponential relationship results:

$$X_1 = a\, X_2^{b_{12.3}} X_3^{b_{13.2}}.$$

Thus, use of logarithmic data implies that the independent variables X_2 and X_3 jointly affect X_1. That is, the separate effects of the independent variables are multiplicative instead of additive. Hence, logarithmic data were used when it was thought that the independent variables jointly and not independently affect X_1.

In certain analyses, factors that cause year-to-year changes in the dependent variable were considered; in others, factors that cause changes from the long-time average. Reasons for the use of these alternative approaches are discussed in connection with each analysis.

Variables used in certain analyses based on year-to-year changes in logarithms were computed by taking the logarithms of link relatives. A link relative is the percentage change from the preceding year for any series. In other analysis, first differences of the logarithms were used. Logarithms of link relatives differ by the characteristic 2 from the first differences of logarithms for the same series. The particular method used is indicated in each instance.

Forecasts based upon an extrapolated regression relationship are risky and must be used cautiously. For this reason, it is important for an analyst to know whether a particular application of a regression relationship involves extrapolation. Further, as the risk of forecast increases with the extent of extrapolation, he should know how much of an extrapolation is involved.

Waugh and Been (*21*) have suggested computation of a chi-square for each combination of values of the independent variables used in the regression analysis.[24] For example, if an analysis were based upon data for 1922–40, using as the dependent variable X_1 and as independent variables X_2, X_3, and X_4, a chi-square could be computed for the $X_2X_3X_4$ combination of values for each year in the analysis. When the values of all independent variables are at their means, chi-square equals zero. As the values depart from their means, chi-square increases. However, chi-square also depends upon the structure of intercorrelation among the independent variables, X_2, X_3, and X_4, in such a way that it indicates the position of an $X_2X_3X_4$ combination of values for a given year with respect to the grouping tendency of all the $X_2X_3X_4$ combinations used in the analysis, as defined by the pattern and degree of concentration of these combinations.

Each chi-square indicates the probability of occurrence of a given combination of the independent variables, or one farther from the grouping tendency, in sampling from the universe implied by the scatter of the data upon which the regression equation was based. Hence, the highest chi-square computed for the $X_2X_3X_4$ combinations in the base period defines the outside limit of the scatter of the data upon which the regression equation was based. If the chi-square computed for the $X_2X_3X_4$ combination used in forecasting X_1 for a given year is higher than the highest chi-square computed for the combination in the base period, application of the regression relationship for that year involves an extrapolation. The higher the chi-square the greater the extrapolation.

The standard error of a forecast provides a method of estimating the probable statistical error involved in a forecast for any given year. This allows for the statistical precision of the regression relationship, the extent to which each independent variable differs from its mean in that year, and the average size of the unexplained residuals for the years included in the analysis. If for the period forecasted no change has occurred in the nature of the relationships prevailing in the period on which the analysis was based, there is a 67-percent chance that the estimated value, plus or minus the standard error of forecast, will include the actual value of the dependent variable for any given year, and a 95-percent chance that the estimated value, plus or minus twice the standard error of forecast, will include the actual value.

Chi-square values and standard errors of forecast for recent years are shown for each of the major analyses.

Two types of errors involved in using a regression relationship to make a forecast are worth mentioning. One type pertains to the relationships implied by the regression equation. For example, the relationships determined from the base-period data may not apply to the period for which the forecast is made. This happens when developments in the period for which the forecast is made are sufficiently important to change the base-period relationships.

[24] For a brief discussion and formulation of the chi-square suggested, see Armore and Burtis (*1*, pp. 7-9).

The accuracy of the forecast depends, likewise, upon the values selected for the independent variables. To forecast X_1 from a regression relationship, it is necessary to know or predict the values for the independent variables included in the equation. If these are incorrectly predicted, the forecast will tend to be in error regardless of how accurately the relationships implied by the regression equation apply to the period for which the forecast is made.

NOTE 3.—FATS AND OILS USED IN FOOD PRODUCTS: RELATIONSHIP OF SUPPLY TO DOMESTIC DISAPPEARANCE, EXPORTS, AND END-OF-YEAR STOCKS[25]

Three analyses are presented using the following variables:

X_1—Supply of fats and oils, other than butter and lard, used in food products per capita (pounds) [26]
X_2—Domestic disappearance of these fats and oils per capita (pounds)
X_3—End-of-year stocks of these fats and oils per capita (pounds)
X_4—Exports of these fats and oils per capita (pounds)

The supply variable X_1 was computed as the sum of production during the calendar year, imports, and beginning-of-year stocks of fats and oils (other than butter and lard) used mainly in food, minus use of these items in nonfood products, plus use in food products of other fats and oils. This supply flows into three channels during the year: Domestic disappearance (consumption), exports, and end-of-year stocks. Hence, for each year, X_1 is equal to the sum of X_2, X_3, and X_4.

Arithmetic first-difference analyses for 1921–42 and 1943–51 were run for the four variables in pairs as follows: X_2X_1, X_3X_1, X_4X_1. First differences were used because interest is centered on related movements from one year to the next. Separate analyses were run for the two periods, as relationships have changed greatly since the beginning of World War II, when the United States shifted from a net import basis for total fats and oils in most years to a net export basis. Results are shown in table 14. The data used are given in table 15.

TABLE 14.—*Statistical results from analyses of the relation between supply and disposition of fats and oils used in food products*

Period and correlation measurement	Variables						
	X_1	X_2	X_3	X_4	X_2X_1	X_3X_1	X_4X_1
Based on 1921–42:							
Standard deviation	1.56	1.57	1.09	0.48			
Simple b					0.66	[1] 0.23	[1] 0.10
Standard error of b					.17	.15	.06
r^2					.43	[1] .11	[1] .11
Based on 1943–51:							
Standard deviation	1.80	1.51	1.25	1.12			
Simple b					[1] .36	[1] .30	[1] .35
Standard error of b					.29	.24	.20
r^2					[1] .18	[1] .18	[1] .31

[1] Probability level more than 5 percent; therefore, not significantly different from zero.

[25] These analyses were suggested by Karl Fox, Bureau of Agricultural Economics.
[26] This is the same variable as X_2 in note 5.

TABLE 15.—*Supply and disposition of fats and oils used in food products per capita, 1920–51* [1]

Year	Supply [2]	Domestic disappearance	Stocks, December 31	Exports [3]
	Pounds	*Pounds*	*Pounds*	*Pounds*
1920	21. 3	12. 7	5. 3	3. 3
1921	20. 9	12. 6	4. 2	4. 0
1922	18. 0	13. 0	2. 9	2. 0
1923	16. 9	12. 2	3. 1	1. 6
1924	18. 4	13. 2	3. 6	1. 6
1925	21. 2	16. 6	3. 0	1. 6
1926	22. 8	16. 6	4. 9	1. 4
1927	24. 0	16. 2	6. 3	1. 4
1928	23. 0	16. 4	5. 5	1. 1
1929	23. 8	17. 6	5. 2	. 9
1930	24. 1	17. 9	5. 3	. 9
1931	22. 2	15. 6	5. 8	. 9
1932	22. 1	13. 3	7. 9	1. 0
1933	23. 5	14. 3	8. 5	. 7
1934	22. 6	16. 4	5. 8	. 4
1935	25. 3	19. 8	5. 3	. 2
1936	26. 2	20. 5	5. 6	. 2
1937	27. 6	21. 1	6. 3	. 2
1938	28. 1	20. 8	7. 2	. 2
1939	27. 0	19. 7	7. 1	. 3
1940	25. 0	18. 3	6. 4	. 3
1941	26. 5	20. 6	5. 6	. 3
1942	25. 0	19. 4	5. 2	. 5
1943	26. 6	20. 3	5. 3	1. 1
1944	24. 6	19. 5	4. 5	. 7
1945	25. 7	19. 7	5. 6	. 4
1946	23. 9	19. 6	3. 5	. 7
1947	24. 0	20. 0	3. 2	. 9
1948	26. 1	21. 2	4. 0	. 8
1949	29. 7	21. 7	4. 1	3. 9
1950	30. 6	24. 2	3. 1	3. 3
1951	30. 5	21. 2	5. 2	4. 2

[1] Cottonseed, soybean, corn, peanut, edible olive and oleo oil, oleostearine, oleo stock, and edible tallow. Data computed from unrounded numbers.

[2] Production, imports, and January 1 stocks of these items, minus use of these items in nonfood products, plus use of other fats and oils (except butter and lard) in food products.

[3] Includes shipments to United States territories.

NOTE 4.—COTTONSEED OIL AND OTHER FOOD FATS AND OILS: PRICE RELATIONSHIPS

Three analyses that relate the wholesale price of cottonseed oil to wholesale prices of other food fats and oils are presented. These analyses are based on the following variables:

X_1—Wholesale price of cottonseed oil, crude, tanks, southeastern mills (cents per pound)

X_2—Wholesale price of lard, prime steam, loose, Chicago (cents per pound)

X_3—Wholesale price of butter, 92 score, creamery, New York (cents per pound)

X_4—Average wholesale price of eight other fats and oils used in food [27] weighted by their average domestic disappearance in 1931–40 (cents per pound)

X_5—Bureau of Labor Statistics index of wholesale prices of all commodities (1935–39=100)

Data relating to these variables are shown in table 16. The analyses presented are based on three variables each, as follows:

Analysis I: X_1, X_2, X_5
Analysis II: X_1, X_3, X_5
Analysis III: X_1, X_4, X_5

The purpose of analysis III is to test the validity of the equivalent-price concept for food fats and oils used as ingredients in edible fat and oil products. As discussed in the section Factors That Affect Margins Among Prices of Individual Fats and Oils, prices of cottonseed oil and those of other food fats and oils used as ingredients tend to move up and down together, with margins that represent certain cost factors. If these cost factors did not vary, margins would tend to be relatively constant, and prices of cottonseed oil and of other fats and oils used as ingredients would tend to change by equal amounts. However, if related cost factors changed, price margins would tend to change as a result. Over a period of time, the price of cottonseed oil is believed to change by an amount equal to the sum of the change in the prices of other fats and oils used as ingredients and the change in the price margins brought about by changes in the cost factors.

Analysis III was based on arithmetic first differences, to correspond with the additive effects of the independent variables discussed in the preceding paragraph. First differences were used because in this analysis the emphasis is on the extent to which year-to-year changes in these variables are related. Years used in the analysis were 1922–40. The index of wholesale prices of all commodities was used to represent the various charges, such as costs of labor, that affect the price margins. The objective is to show that, when these costs are held constant, margins tend to remain constant and therefore prices of cottonseed oil and competing fat and oil ingredients fluctuate by equal amounts. Analyses I and II were designed to show that even when these costs are held constant, the price of cottonseed oil is differently related to the prices of lard and butter, reflecting differences in the competitive relationships between these fats and cottonseed oil.

The results, which are shown in table 17, support the concept of equivalent prices. They indicate that during 1922–40 the price of cottonseed oil and the average price of other fats and oils used in food products fluctuated by about equal amounts (analysis III, $b_{14.5}=1.18$). But a 1-cent change in the price of lard during this period was associated with an 0.4-cent change in the price of cottonseed oil (analysis I). Prices of cottonseed oil and butter showed no relationship to each other during this period, after allowing for the effects of the general price level.

The *a* value or constant term in each analysis does not differ significantly from zero. As these analyses were based on first differences, this means that, after allowing for changes in the wholesale price level, the price relationships between cottonseed oil and other

[27] Coconut, corn, oleo, palm, peanut and soybean oils, oleostearine, and edible tallow.

fats and oils used in food products tended to be unchanged during 1922–40.

TABLE 16.—*Wholesale price per pound of cottonseed oil, and other food fats and oils, and index of wholesale price of all commodities, 1921–51*

Year	Cottonseed oil, crude, tanks, f. o. b. Southeastern mills	Lard, prime steam, loose, Chicago	Butter, creamery, New York	Other food fats and oils [1]	Index of wholesale price of all commodities (1935–39=100) [2]
	Cents	*Cents*	*Cents*	*Cents*	
1921	6.2	9.7	43.3	7.4	121.1
1922	8.6	10.4	40.6	8.3	120.0
1923	9.8	11.1	46.9	10.0	124.8
1924	9.1	12.0	42.6	10.2	121.7
1925	9.3	15.6	45.3	10.6	128.4
1926	9.4	13.8	44.4	10.3	124.1
1927	8.3	11.7	47.3	9.4	118.4
1928	8.4	11.2	47.4	9.4	120.0
1929	8.1	10.9	45.0	8.8	118.2
1930	6.9	9.8	36.5	7.5	107.2
1931	5.3	7.2	28.3	5.3	90.6
1932	3.1	4.2	21.0	3.7	80.4
1933	3.7	4.8	21.7	4.2	81.8
1934	5.6	7.4	25.7	5.7	92.9
1935	9.2	13.6	29.8	8.8	99.3
1936	8.6	10.7	33.0	8.4	100.2
1937	8.0	11.1	34.4	9.0	107.1
1938	6.7	7.7	28.0	6.6	97.5
1939	5.6	6.0	26.0	6.0	95.7
1940	5.3	5.0	29.5	5.6	97.5
1941	9.5	8.6	34.3	9.0	108.3
1942	12.7	11.8	40.1	11.6	122.6
1943	12.8	12.8	44.8	11.7	127.9
1944	12.8	12.5	42.2	11.7	129.1
1945	12.8	12.8	42.8	11.5	131.3
1946	15.8	19.1	62.8	15.5	150.2
1947	25.9	22.5	71.3	22.9	188.7
1948	25.3	20.3	75.8	24.5	204.8
1949	11.6	11.3	61.5	13.5	192.3
1950	15.8	11.8	62.2	15.6	200.4
1951	18.4	16.1	69.9	18.4	223.8

[1] Average price of eight fats and oils used in food other than cottonseed oil, lard, and butter weighted by their average domestic disappearance in 1931–40.
[2] Bureau of Labor Statistics.

Compiled from the Oil, Paint and Drug Reporter (*9*), the National Provisioner, (*7*), and reports of the Production and Marketing Administration and the Bureau of Labor Statistics.

Table 18 shows first differences for the price of cottonseed oil for the years used in the analysis and for subsequent years and estimated first differences based on analyses I and III. In addition, chi-squares and net residuals for each year and standard errors of forecast for 1941–51 are presented.

The largest chi-square for the independent variables used in analysis I for the base period 1922–40 is 8.48, computed for 1935. Thus, a chi-square larger than 8.48 involves an extrapolation. The extrapolation involved in estimating the price of cottonseed oil on the basis

of analysis I is considerable for 1946–49 and 1951.[28] Prices rose generally after price controls were removed in the latter part of 1946. The price of cottonseed oil rose sharply between 1946 and 1947 and in the latter year it was considerably out of line with the price of lard and with the general level of wholesale prices (note the relative size of the net residual and standard error of forecast for that year). Wholesale prices dropped sharply in 1949. However, as indicated by the net residual and standard error of forecast, the decline in prices of cottonseed oil was greater than would have been expected on the basis of analysis I. This probably reflects, in part, the reaction to the sharper rise in the price of cottonseed oil in 1947. In 1951, a tight supply situation and an unusually strong domestic and foreign demand reflecting in part a building-up of inventories, caused prices of fats and oils to increase more than normally in relation to the general level of wholesale prices.

TABLE 17.—*Statistical results from analyses of the relation between prices of specified fats and oils* [1]

Correlation measurement	Variables											
	Analysis I				Analysis II				Analysis III			
	X_1X_2	X_1X_3	X_2X_3	$X_1X_2X_3$	X_1X_2	X_1X_3	X_2X_3	$X_1X_2X_3$	X_1X_2	X_1X_3	X_2X_3	$X_1X_2X_3$
Partial b	0.40	[2] 0.04			[2] 0.01	[2] 0.14			1.18	[2] 0.05		
Standard error of the b	.12	.04			.11	.07			.21	.04		
Partial r [2]	.41	[2] .06			([3]) ([2])	[2] .19			.66	[2] .08		
Simple r [2]	.66	.46	.51		.34	.46	.72		.80	.46	.70	
R^2				.68				.46				.82
Standard error of estimate				.88				1.14				.66
a [4]				[2] .10				[2] .12				([3])

[1] Arithmetic first-difference analyses using years 1922–40.
[2] Probability level more than 5 percent when sampling from a population whose true correlation is zero; therefore, not significantly different from zero.
[3] Less than 0.005.
[4] Constant value in the regression equation.

The largest chi-square for the independent variables in analysis III for the base period 1922–40 is 8.42, computed for 1935. Use of this analysis to estimate the price of cottonseed oil involves a considerable extrapolation for 1947, 1949, and 1951. The sharp rise in the price of cottonseed oil in 1947 was higher than would have been indicated by this analysis. This rise reflected the short supply of the oil and the concern of producers of edible fat and oil products over meeting their nonsubstitutable demand for this oil. That is, the rise in the price of cottonseed oil was out of line with the rise in the average price of food fats and oils other than cottonseed oil, butter, and lard, as indicated by the net residual and standard error of forecast for analysis III for that year. The 1949 decline in the price of cottonseed oil was approximately in line with the decline in the average price of food fats and oils other than cottonseed oil, butter, and lard.

[28] The theoretical probability of each chi-square may be found in a chi-square table. Such tables are given in many texts on statistical method. See, for example, Fisher (*4*, pp. 110–111) or Snedecor (*18*, p. 163).

TABLE 18.—*Cottonseed oil, wholesale price per pound: Actual and computed arithmetic first differences, and selected correlation measures, 1922–51*

Year	Observed price	Estimated from the Bureau of Labor Statistics index of wholesale prices for all commodities and [1]—							
		Price of lard				Average price of fats and oils used in food products			
		Estimated price of cottonseed oil	Residual [2]	Chi-square [3]	Standard error of forecast [3]	Estimated price of cottonseed oil	Residual [2]	Chi-square [3]	Standard error of forecast [3]
	Cents	*Cents*	*Cents*		*Cents*	*Cents*	*Cents*		*Cents*
1922	2.37	0.32	2.05	0.26		1.12	1.25	1.78	
1923	1.20	.58	.62	.80		1.78	−.58	2.02	
1924	−.65	.34	−.99	.07		.39	−1.04	.73	
1925	.18	1.82	−1.64	2.48		.15	.03	2.26	
1926	.11	−.80	.91	.40		−.15	.26	.34	
1927	−1.15	−.97	−.18	.58		−.78	−.37	.41	
1928	.07	−.02	.09	.44		−.08	.15	.37	
1929	−.28	−.12	−.16	.01		−.62	.34	.31	
1930	−1.22	−.76	−.46	2.79		−1.00	−.22	2.11	
1931	−1.57	−1.65	.08	5.27		−1.80	.23	4.86	
1932	−2.19	−1.50	−.69	1.07		−1.40	−.79	1.59	
1933	.56	.40	.16	.15		.53	.03	.20	
1934	1.91	1.58	.33	2.98		1.24	.67	3.19	
1935	3.65	2.87	.78	8.48		3.36	.29	8.42	
1936	−.60	−1.01	.41	3.46		−.52	−.08	.82	
1937	−.61	.51	−1.12	1.99		.38	−.99	1.91	
1938	−1.30	−1.65	.35	1.78		−2.38	1.08	3.09	
1939	−1.15	−.64	−.51	.57		−.62	−.53	.31	
1940	−.29	−.23	−.06	.94		−.50	.27	1.28	
1941 [4]	4.21	1.98	2.23	3.09	0.97	3.51	.70	7.48	0.80
1942 [4]	3.22	2.00	1.22	4.73	1.00	2.39	.83	4.81	.76
1943 [4]	.05	.70	−.65	.88	.92	−.14	.19	2.09	.72
1944 [4]	0	.04	−.04	.21	.91	.06	−.06	.26	.69
1945 [4]	0	.30	−.30	.26	.91	−.34	−.34	.98	.70
1946 [4]	3.05	3.30	−.34	10.19	1.11	3.82	−.77	9.42	.83
1947 [4]	10.12	3.04	7.08	43.64	1.61	6.90	3.22	33.05	1.11
1948 [4]	−.66	−.14	−.52	19.02	1.26	1.11	−1.77	7.73	.80
1949 [4]	−13.63	−3.99	−9.64	14.54	1.19	−12.43	−1.20	155.02	2.02
1950 [4]	4.17	.53	3.64	2.50	.06	2.09	2.08	2.64	.73
1951 [4]	2.60	2.68	−.08	12.62	1.15	2.18	.42	13.71	.88

[1] From analyses I and III; based on data in table 16.
[2] Observed value minus estimated value.
[3] For formula, see Arrow and Burtis (*1*, p. 9).
[4] These years not used in analysis.

NOTE 5.—FOOD FATS AND OILS: FACTORS THAT AFFECT PRICE

This analysis was based on the calendar years 1922–42 and 1947–51, using the following variables:

X_1—Wholesale price of edible fats and oils, excluding butter and lard, at leading markets, index numbers (1947–49=100)
X_2—Supply of fats and oils used in food products, excluding butter and lard, per capita (pounds). The separate items used in computing this variable are shown in table 2.
X_3—Supply of lard per capita (pounds)
X_4—Personal disposable income per capita (dollars)

Data relating to these variables are shown in table 19 and results of the analysis are shown in table 20.

The three independent variables are believed to affect prices jointly and the relationships are believed to be more stable in percentage than in absolute terms. For this reason, all of the variables were converted to logarithms. As emphasis in this bulletin is placed on the effects on price of a permanent increase in the supply of food fats and oils due to improved processing techniques for oilseeds, rather than on the effects

of year-to-year changes in supply, the analysis was based on deviations from average rather than on first differences. A further reason for using deviations from average is that year-to-year changes in the supply variables are too small to give a reliable estimate of the slope of the regression line. Variations in terms of deviations from average are several times as large.

Because of the importance of this analysis, a number of closely related alternative analyses were run. Results from these are shown in table 20, along with those from the one adopted for final use. An analysis similar to the final one was first run, omitting the post-World War II years. Examination of a chart similar to that shown in figure 4 indicated that the regression line for income was somewhat too steep for the postwar years and that the residuals for these years probably would be considerably reduced by including the postwar years in the analysis. These years did not, however, appear to be part of a different universe. As shown in table 20, most of the adjustment actually came in the regressions on supply. As this analysis was based on actual data instead of first differences and time trends were known to have been important for certain variables, time was added as a fourth independent variable in the analysis excluding the postwar years. The coefficient of partial determination for time in this analysis was almost zero and the partial regression coefficients for the other variables did not change greatly, so this item was omitted from the final analysis.

When the final analysis was completed, the residuals appeared to be correlated with *changes* in the general price level and with changes in prices of fats and oils. As discussed in the body of this bulletin, accumulation and reduction of inventories by members of the fats and oils trade during periods of changing prices would be expected to have such an effect. To throw more light on this point, year-to-year changes in the dependent variable were added as a fourth independent variable. The multiple coefficient of determination was raised from 0.92 to 0.96, so that the unexplained variation was reduced from 8 to 4 percent, and a statistically significant partial coefficient of determination of 0.52 was obtained for the new variable. The addition of this variable has little longer-term forecasting value but it does confirm the importance of allowing for the effects of changes in inventories in making short-term forecasts.

All of these analyses indicated an inelastic demand for edible fats and oils, excluding butter and lard. On first thought, one might expect that the demand would be elastic because of the competition between shortening and lard and between margarine and butter. However, supply of lard has been held constant (statistically) in this analysis by the inclusion of supplies of lard as an independent variable. With any *given* supply of lard, demand for edible fats and oils would be expected to be inelastic. As indicated in figure 1, consumption of these products is stable from year to year and there are few close substitutes for them. This analysis measures elasticity at the wholesale rather than the retail level and represents the total demand for these products, including that for export and storage, rather than for consumption only. Further research would be required to ascertain the elasticity of demand for the several alternative outlets.

Table 19 includes the actual and calculated price indexes and chi-squares for the "final" analysis for each year and the standard errors

of forecast for 1941–51. The chi-squares indicate that extrapolation is involved for none of the years omitted from the analysis.

TABLE 19.—*Edible fats and oils, excluding butter and lard: Actual and computed index numbers of wholesale prices and related variables, 1922–51*

Year	X_1 Price [1]		X_2 Supply of fats and oils used in food products per capita [2]	X_3 Supply of lard per capita	X_4 Personal disposable income per capita	Chi-square [4]	Standard error of forecast [4]	
	Actual	Computed [3]					Percentage of computed value	Actual
			Pounds	*Pounds*	*Dollars*		*Percent*	
1922	44	46	18.0	21.2	533	4.38		
1923	47	51	16.9	24.6	606	6.64		
1924	47	46	18.4	23.6	601	3.77		
1925	43	50	21.2	19.0	627	1.13		
1926	51	46	22.8	19.0	641	.17		
1927	44	41	24.0	19.3	635	.28		
1928	44	41	23.0	20.7	644	.65		
1929	43	41	23.8	20.8	673	.91		
1930	37	39	24.1	18.7	595	.25		
1931	28	35	22.2	18.9	505	.56		
1932	20	23	22.1	10.4	381	2.72		
1933	22	19	23.5	19.9	358	5.53		
1934	30	27	22.6	17.5	406	1.51		
1935	44	45	25.3	10.9	453	9.75		
1936	42	40	26.2	13.4	513	2.74		
1937	43	45	27.6	12.2	548	4.55		
1938	35	34	28.1	13.6	501	2.01		
1939	31	33	27.0	16.3	533	1.62		
1940	30	35	25.0	18.4	560	.77		
1941	51	40	20.5	18.8	686	1.25	14.4	6
1942	64	59	25.0	19.2	860	.56	14.2	8
1943 [5]	64	55	26.6	21.6	963	2.96	14.9	8
1944 [5]	65	62	24.6	24.1	1,055	3.95	15.1	9
1945 [5]	65	82	25.7	17.0	1,073	1.96	14.6	12
1946 [5]	80	111	23.9	15.9	1,117	6.86	15.9	13
1947	122	106	24.0	17.5	1,160	4.83	15.4	16
1948	119	107	26.1	17.1	1,277	4.25	15.2	16
1949	88	78	29.7	18.2	1,243	3.43	15.0	12
1950	75	83	30.6	18.2	1,339	4.38	15.3	13
1951	89	85	30.5	19.6	1,434	5.45	15.5	13

[1] Index numbers, 1947–49=100.
[2] Based on the analysis discussed in this note.
[3] See table 2 for items included.
[4] For formula, see Armore and Burtis (*1*, p. 9).
[5] These years omitted from analysis.

TABLE 20.—*Statistical results from alternative analyses of factors that affect prices of edible fats and oils, excluding butter and lard*

Correlation measurement	Analysis			
	Excluding postwar years		Including postwar years	
	Excluding time	Including time	Excluding change in price [1]	Including change in price
$b_{12.345} \pm s_{b_{12.345}}$	−1.23±.27	−1.10±.38	−1.57±.27	−1.34±.20
$b_{13.245} \pm s_{b_{13.245}}$	−.03±.18	−.92±.18	−1.11±.20	−.03±.15
$b_{14.235} \pm s_{b_{14.235}}$	1.44±.12	1.43±.13	1.37±.09	1.29±.06
$b_{15.234} \pm s_{b_{15.234}}$		[2]−.0015±.0028		.33±.07
$r^2_{12.345}$	.56	.35	.60	.68
$r^2_{13.245}$	.61	.61	.58	.66
$r^2_{14.235}$	.80	.88	.01	.95
$r^2_{15.234}$		[2].02		.52
$R^2_{1.2345}$	.89	.80	.92	.96
$s_{1.2345}$	.046	.047	.056	.040
d	.49	.33	1.37	1.66

[1] Analysis used in obtaining computed values, chi-squares, and standard error of forecast in table 19 and on which figure 4 is based.
[2] Probability level more than 5 percent; therefore not significantly different from zero.

NOTE 6. COTTONSEED OIL: RELATION OF PRICE TO THAT FOR EDIBLE FATS AND OILS, OTHER THAN BUTTER AND LARD

The analysis is based on the following variables:

X_1—Price of cottonseed oil per pound, crude, tanks, f. o. b. Southeastern mills (cents)
X_2—Wholesale price of edible fats and oils, excluding butter and lard, leading markets, index numbers (1947–49=100)
X_3—Bureau of Labor Statistics index of wholesale prices of all commodities (1935–39=100)

This analysis was designed to apply results from the analysis discussed in note 5 to cottonseed oil. For this reason, the same years—1922–42 and 1947–51—were used and the variables were converted to logarithms. Part of the relationship between prices of cottonseed oil and those of all edible fats and oils reflects the common influence of the general price level. To measure the direct relationship between the first two variables, the partial correlation and regression coefficients were obtained. These measure the relationship between the two series after allowing for the effects of the wholesale price level on each series. In this instance, the partial and simple correlation and regression coefficients are almost identical. This analysis is designed primarily to measure relationship between two associated series. It would not be used to "forecast" one from the other. Therefore, the standard errors of forecast are not given.

Results from this analysis are shown in table 21. The original data are given in tables 16 and 19.

TABLE 21.—*Statistical results from an analysis of the relation between prices of cottonseed oil and of all edible fats and oils, excluding butter and lard*

Correlation measurement	Variables			
	X_1 X_2	X_1 X_3	X_2 X_3	X_1 X_2 X_3
Partial b	1. 16	[1] −0. 04		
Standard error of the b	. 24	. 36		
Partial r^2	. 96	[1] . 01		
Simple b	1. 14			
Simple r^2	. 99	. 82	0. 83	
R^2				0. 99
Standard error of estimate				. 020
a				−. 90

[1] Probability level more than 5 percent; therefore, not significantly different from zero.

NOTE 7. YIELD OF COTTONSEED OIL PER TON OF COTTONSEED PROCESSED: RELATION TO PRICE OF COTTONSEED OIL AND QUANTITY OF COTTONSEED PROCESSED

The analysis is based on the following variables:

X_1—Yield of cottonseed oil per ton of cottonseed processed (pounds)
X_2—Wholesale price of cottonseed oil, crude, tanks, Southeastern mills, divided by the Bureau of Labor Statistics index of wholesale prices of all commodities, 1935–39=100 (cents per pound)
X_3—Quantity of cottonseed processed (1,000 tons)

The purpose of this analysis is to ascertain whether the relation of the quantity of cottonseed oil obtained per ton of seed processed to changes in the wholesale price of the oil and in the quantity of seed processed can be measured statistically.

TABLE 22.—*Yield of cottonseed oil and meal per ton of cottonseed processed, wholesale price of all commodities, and quantity of cottonseed processed, 1920–51*

Year beginning August	Cottonseed oil		Cottonseed meal		Cottonseed processed	Wholesale price of all commodities, Bureau of Labor Statistics (1935–39=100)
	Yield per ton of cottonseed processed	Wholesale price per pound, crude, tanks, f. o. b. Southeastern mills	Yield per ton of cottonseed processed	Wholesale price per ton, 41 percent protein, bagged, Memphis		
	Pounds	*Cents*	*Pounds*	*Dollars*	*1,000 tons*	
1920	322	6. 9	878	35. 95	4, 069	146. 6
1921	309	8. 3	901	41. 05	3, 008	116. 8
1922	309	9. 0	918	41. 95	3, 242	125. 4
1923	296	9. 2	918	42. 55	3, 308	121. 5
1924	305	9. 5	923	39. 05	4, 605	125. 6
1925	291	10. 1	934	33. 60	5, 558	126. 7
1926	299	7. 8	901	30. 75	6, 306	119. 8
1927	317	8. 8	900	45. 65	4, 654	119. 6
1928	317	8. 4	902	41. 40	5, 061	119. 3
1929	313	7. 3	890	36. 70	5, 016	113. 6
1930	306	6. 4	918	26. 60	4, 715	96. 8
1931	318	3. 2	901	13. 70	5, 328	83. 8
1932	313	3. 5	906	15. 80	4, 621	78. 5
1933	313	4. 1	909	21. 70	4, 157	89. 9
1934	312	8. 5	910	32. 30	3, 550	97. 3
1935	305	8. 6	911	22. 40	3, 818	99. 5
1936	303	9. 2	903	34. 35	4, 498	105. 6
1937	310	6. 6	895	22. 40	6, 326	101. 3
1938	315	6. 0	905	22. 15	4, 471	95. 4
1939	319	5. 6	907	27. 60	4, 151	97. 3
1940	324	6. 5	888	26. 65	4, 398	101. 4
1941	312	12. 3	874	36. 60	4, 008	118. 5
1942	311	12. 8	887	37. 90	4, 498	126. 4
1943	313	12. 8	928	48. 55	3, 955	128. 5
1944	311	12. 8	919	48. 50	4, 252	130. 3
1945	312	12. 8	879	55. 05	3, 262	135. 8
1946	315	24. 8	882	74. 55	3, 088	175. 6
1947	313	26. 3	930	86. 80	4, 083	200. 9
1948	320	15. 4	897	63. 30	5, 334	199. 5
1949	323	12. 5	895	63. 20	5, 711	191. 0
1950	321	20. 4	896	77. 70	3, 724	220. 0
1951	319	13. 0	930	83. 87	5, 469	216. 8

Yield and quantity of cottonseed processed from *Cotton Production and Distribution* (*17*). Cottonseed oil price from the *Oil, Paint and Drug Reporter* (*19*); cottonseed meal price from reports of Production and Marketing Administration.

If the price of oil and the quantity processed measurably affect the yield of oil, these effects would probably operate jointly. For example, the yield of the oil in part depends upon pressing and drainage time. As storability of cottonseed is limited, a large quantity of seed on

hand for processing would tend to reduce pressing and drainage time, particularly if the processing capacity of the mill were limited relative to the quantity to be processed. Hence, if an increase in the price of cottonseed oil tended to increase the yield of oil, this increase might depend upon the quantity of cottonseed to be processed and the processing capacity of the mill. Data as to the processing capacity of mills are not available, but they are believed to be fully adequate in most years and in most territories.

The analysis was based upon logarithms of link relatives of X_1, X_2, and X_3, which implies that any effects on yield of the price of the oil and the quantity of seed processed operate jointly. Link relatives were used because emphasis in this analysis is on factors that cause changes from one year to the next. The years 1921–40 were used in the analysis. Data relating to these variables are shown in table 22. As data on stocks in relation to capacity at individual mills were not available, the total quantity of cottonseed processed in the United States was used as a rough substitute variable.

Results from this analysis are shown in table 23.

These results indicate that the effect of changes in the price of the oil and of changes in the quantity of seed processed on the quantity of cottonseed oil obtained per ton of seed processed were not measurable. These results probably reflect in part the fact that the importance of these factors is slight and in part that such important variables as quality of seed and type of processing equipment on hand could not be included in the analysis because of lack of data.

TABLE 23.—*Statistical results from an analysis of factors that affect the yield of cottonseed oil per ton of seed crushed.*

Correlation measurement	Variables			
	X_1X_3	X_2X_3	X_3X_3	$X_1X_2X_3$
Partial b	[1] −0.06	[1] −0.03		
Standard error of the b	.03	.04		
Partial r^2	[1] .18	[1] .03		
Simple r^2	[1] .16	([2])	0.26	
R^2				[1] 0.18
Standard error of estimate				.01
a				2.17

[1] Probability level more than 5 percent; therefore, not significantly different from zero.

[2] Less than 0.005.

NOTE 8. YIELD OF COTTONSEED MEAL PER TON OF COTTONSEED PROCESSED: RELATION TO PRICE OF COTTONSEED MEAL AND QUANTITY OF COTTONSEED PROCESSED

The analysis is based on the following variables:

X_1—Yield of cottonseed meal per ton of cottonseed processed (pounds).

X_2—Wholesale price of cottonseed meal, 41-percent protein, bagged, Memphis, divided by the Bureau of Labor Statistics index of wholesale prices for all commodities, 1935–39=100 (dollars per ton).

X_3—Quantity of cottonseed processed (1,000 tons).

The analysis was based on logarithms of link relatives for 1921–40. Results are shown in table 24. Data relating to these variables are shown in table 22, Appendix note 7.

Results are similar to those obtained in note 7 for yields of cottonseed oil. It can be presumed that they reflect similar causes.

TABLE 24.—*Statistical results from an analysis of factors that affect the yield of cottonseed meal per ton of seed crushed.*

Correlation measurement	Variables			
	X_1X_2	X_1X_3	X_2X_3	$X_1X_2X_3$
Partial b	([1] [2])	[2] −0. 03		
Standard error of the b	0. 02	. 02		
Partial r^2	([1] [2])	[2]. 11		
Simple r^2	[2]. 05	. 15	0. 39	
R^2				[2] 0. 15
Standard error of estimate				. 01
a				2. 07

[1] Less than 0.005.

[2] Probability level more than 5 percent; therefore, not significantly different from zero.

NOTE 9. SEASON AVERAGE PRICE OF COTTONSEED RECEIVED BY FARMERS: RELATION TO COMBINED VALUE OF MAJOR PRODUCTS OF COTTONSEED PROCESSING

This analysis is based on the crop years beginning 1922–40, using the following variables:

X_1—Season average price of cottonseed received by farmers, year beginning August (dollars per ton).

X_2—Combined wholesale value of the oil, meal, hulls, and linters obtained per ton of seed processed, year beginning August (dollars).

Combining the yield values for the major cottonseed products into one variable (X_2) implies that a given change in the value of the yield of any of the products would have the same effect on the price of cottonseed as would an equal change in value of the yield of any other product. A linear relationship between X_1 and X_2 using actual values rather than first differences was assumed. A similar analysis based on first differences gave almost the same results. Data on which the analyses were based appear in table 25.

Data on prices used in table 25 for cottonseed products are simple averages for the 12 months during the marketing year. A better series for this purpose could have been obtained by weighting the price of each product in each month by the disappearance of that product from the mills or by weighting by some other system that would allow for forward sales of the products. For purposes of this analysis, however, this additional refinement did not appear to justify the work involved. The Bureau of the Census, in its annual report on production and distribution of cotton (*17*), publishes the total value of products obtained per ton of seed, but no breakdown is given for the individual products.

TABLE 25.—*Cottonseed: Season average price per ton, and yield, wholesale price per pound, and value of the oil, meal, hulls, and linters per ton of seed processed, 1922–51*

Year beginning August	Cottonseed, season average price	Per ton of seed processed												Total value of products
		Oil			Meal			Hulls			Linters			
		Yield	Price[1]	Value	Yield	Price[1]	Value	Yield	Price[1]	Value	Yield	Price[1]	Value	
	Dol.	*Lb.*	*Ct.*	*Dol.*	*Lb.*	*Ct.*	*Dol.*	*Lb.*	*Ct.*	*Dol.*	*Lb.*	*Ct.*	*Dol.*	*Dol.*
1922	30.42	309	9.02	27.87	918	2.10	19.28	582	0.47	2.74	99	5.01	5.32	55.21
1923	41.23	296	9.20	27.23	918	2.13	19.55	560	.65	3.70	97	6.88	6.67	57.15
1924	33.25	305	9.54	29.10	923	1.95	18.00	578	.48	2.77	93	4.95	4.60	51.47
1925	31.59	291	10.05	29.25	934	1.68	15.69	557	.44	2.45	96	4.35	4.18	51.57
1926	22.04	299	7.77	23.23	901	1.51	13.58	588	.34	2.00	88	3.00	2.64	41.75
1927	34.83	317	8.75	27.74	960	2.28	20.52	507	.34	1.94	105	5.09	5.34	55.53
1928	34.17	317	8.43	26.75	992	2.07	18.67	511	.37	2.09	122	4.50	5.49	52.91
1929	30.92	313	7.29	22.82	866	1.84	16.38	552	.46	2.54	119	3.37	4.01	45.75
1930	22.04	306	6.41	19.61	918	1.33	12.21	563	.46	2.54	101	1.89	1.91	36.27
1931	8.97	318	3.19	10.14	901	.69	6.22	567	.35	1.98	97	1.30	1.26	19.60
1932	10.33	313	3.51	10.99	906	.78	7.10	568	.26	1.14	95	1.30	1.24	20.53
1933	12.88	313	4.07	12.74	909	1.09	9.91	531	.21	1.12	114	3.35	3.82	27.59
1934	33.60	312	8.48	26.46	910	1.62	14.74	514	.61	3.14	130	4.32	5.88	50.22
1935	30.54	305	8.63	26.32	911	1.12	10.20	518	.56	2.89	138	3.83	5.31	44.42
1936	33.36	303	9.15	27.72	903	1.72	15.53	509	.67	2.90	151	4.23	6.39	52.54
1937	19.51	310	6.60	20.46	895	1.12	10.02	514	.36	1.85	130	2.05	2.89	35.22
1938	21.79	315	5.96	18.77	905	1.11	10.05	519	.42	2.18	140	1.78	2.65	33.65
1939	21.17	310	5.61	17.99	907	1.33	12.52	508	.56	2.84	155	2.85	4.42	37.77
1940	21.73	324	6.54	21.19	888	1.33	11.81	501	.55	2.77	165	3.63	5.99	41.76
1941	47.65	312	12.27	38.28	874	1.83	15.99	495	.50	2.48	179	4.50	8.06	64.81
1942	45.61	311	12.75	39.65	887	1.89	16.76	482	.51	2.46	183	4.41	8.07	66.94
1943	52.10	313	12.75	39.91	928	2.43	22.55	469	.60	2.81	178	4.35	7.74	73.01
1944	52.70	311	12.75	39.65	919	2.42	22.24	463	.65	3.01	176	4.40	7.74	72.64
1945	51.10	312	12.75	39.78	879	2.75	24.17	480	.66	3.17	182	4.58	8.34	75.46
1946	72.00	315	24.78	78.06	882	3.73	32.90	471	.80	3.77	191	9.46	18.07	132.80
1947	85.90	313	26.25	82.16	930	4.34	40.36	452	.78	3.53	186	6.70	12.46	138.51
1948	67.20	320	15.42	49.34	897	3.10	28.35	463	.53	1.63	183	3.94	7.21	80.43
1949	43.40	323	12.52	40.44	895	3.16	28.28	469	.35	1.64	176	5.61	9.87	80.23
1950	86.60	321	20.39	65.45	896	3.88	34.76	461	.99	4.15	185	16.21	29.99	134.35
1951	69.30	319	12.98	41.41	930	4.10	38.07	451	.87	3.92	159	[2] 8.66	13.77	98.07

[1] Simple average price per pound for the 12 months in the marketing year beginning August, using the following quotations: Cottonseed oil, crude, f. o. b. Southeastern mills; cottonseed meal, 41-percent protein, bagged, carlots, Memphis, cottonseed hulls, carload lots, Atlanta; linters, weighted average price for all grades and market points, f. o. b. mill.

[2] Preliminary.

Compiled from reports of the Bureau of the Census, the Production and Marketing Administration, the Bureau of Agricultural Economics, the Oil, Paint and Drug Reporter (*9*), and the New York Journal of Commerce (*8*).

To indicate whether a weighted average price series would have given results different from those obtained by using a simple average of prices, an analysis was run using the census data in place of the series on total value of products shown in table 25, based on the same years as used in the analysis discussed above. The statistical coefficients obtained were about the same as for the analysis used in this study. Thus it appears that this analysis gives satisfactory results when interest is centered on the average or normal relationship between prices received by farmers for cottonseed and the value of the products obtained from the seed. For any given year, results from the two analyses might differ considerably.[20]

[20] For a discussion of some of the problems involved in measuring marketing margins for cottonseed, see Parr and Been (*10*) and Sabin (*11*).

The following results were obtained:

Statistical coefficients

b_{12}	0.74
Standard error of b_{12}	.05
r^2_{12}	.93
Standard error of estimate	2.48
a	−5.81

Table 26 shows the actual and calculated season average prices of cottonseed received by farmers for the years used in the analysis and subsequent years. In addition, the standard errors of forecast for 1941–51 are shown.

TABLE 26.—*Cottonseed, season average price per ton received by farmers: Actual, computed and net residuals, 1922–51, and standard error of forecast,* 1941–51

Year beginning August	Actual price	Computed price [1]	Residual [2]	Standard error of forecast [3]
	Dollars	*Dollars*	*Dollars*	*Dollars*
1922	30.42	35.17	−4.75	
1923	41.23	36.61	4.62	
1924	33.25	34.62	−1.37	
1925	31.59	32.47	−.88	
1926	22.04	25.18	−3.14	
1927	34.83	35.41	−.58	
1928	34.17	33.47	.70	
1929	30.92	28.15	2.77	
1930	22.04	21.11	.93	
1931	8.97	8.74	.23	
1932	10.33	9.43	.90	
1933	12.86	14.67	−1.79	
1934	33.00	31.47	1.53	
1935	30.64	27.16	3.38	
1936	33.36	33.19	.17	
1937	19.51	20.33	−.82	
1938	21.79	19.17	2.62	
1939	21.17	22.23	−1.06	
1940	21.73	25.19	−3.46	
1941 [4]	47.65	42.31	5.34	2.77
1942 [4]	45.61	43.91	1.70	2.81
1943 [4]	52.10	48.34	3.76	2.95
1944 [4]	52.70	48.15	4.55	2.94
1945 [4]	51.10	52.51	−1.41	3.10
1946 [4]	72.00	92.76	−20.76	5.15
1947 [4]	85.90	96.82	−10.92	5.39
1948 [4]	67.20	58.35	8.85	3.34
1949 [4]	43.40	53.72	−10.32	3.15
1950 [4]	86.60	93.93	−7.33	5.22
1951 [4]	69.30	66.83	2.47	3.74

[1] From the analysis presented in this note.
[2] Actual price minus computed price.
[3] For formula see Ezekiel (*3*, p. 342).
[4] These years not used in the analysis.

Compared with the range of values for X_2 ($19.60 to $57.15) for the years included in the analysis, the value for each crop year 1941 through 1951 represents an extrapolation of the independent variable, as shown in table 25. However, the observed value for X_1 is within one or two standard errors of forecast for the 1941–45 and 1950–51 seasons, and within three standard errors of forecast for the 1947–48 seasons. The season average price paid to farmers for cottonseed in the 1946 season was substantially out of line with the value of the major cottonseed products as indicated by the analysis. This may be accounted for by the lifting of price controls in October 1946, and the accompanying price advances for the major cottonseed products. Farmers sold most of their cottonseed crop early in the season before price controls were removed. Hence, an unusual relationship between the price of cottonseed and the value of the major cottonseed products resulted.

Note 10.—Cottonseed Crop, Less Use for Planting: Factors That Affect Percentage Sold to Mills

This analysis was based on the crop years beginning 1922–40, using the following variables:

X_1—Percentage of the cottonseed crop, less use for planting, sold to mills, year beginning August (percent)
X_2—Season average price per ton received by farmers for cottonseed (dollars)
X_3—Index of prices paid by farmers, including commodities, interest, taxes, and wage rates, year beginning August (1910–14=100).

Data relating to these variables are presented in table 27 and results of the analysis are given in table 28.

The primary purpose of this analysis is to estimate the relationship between changes in the price received by farmers for cottonseed and changes in the percentage of the crop, less use for planting, sold to mills. The independent variables X_2 and X_3 probably jointly affect the percentage delivered to the mills and interest in this study is concentrated on factors that cause year-to-year changes in the dependent variable. Hence, the variables were converted to logarithms of link relatives.

Table 27 shows the actual and calculated percentages of the cottonseed crop, less use for planting, sold to mills, chi-squares for each year, and the standard errors of forecast for 1941–51.

Except for the crop year 1942, application of the analysis to the 1941–51 seasons does not involve extrapolation of the independent variables. The percentages sold for the 1941–51 seasons, which were not used in the analysis, are generally in line with the estimates indicated by the analysis.

TABLE 27.—*Cottonseed crop, less use for planting: Actual and computed percentage sold to mills, and related variables, 1921–51*

Year beginning August	X_1 Percentage sold to mills		X_2 Season average price per ton of cottonseed received by farmers	X_3 Price paid by farmers for all commodities, including interest, taxes, and wage rates [2]	Chi-square [3]	Standard error of forecast [3]	
	Actual	Computed [1]				Percentage of computed value	Actual
	Percent	*Percent*	*Dollars*			*Percent*	*Percent*
1921	95. 6	------	29. 14	153	------	------	------
1922	85. 5	94. 8	30. 42	156	0. 25	------	------
1923	84. 4	98. 8	41. 23	160	. 69	------	------
1924	85. 7	86. 8	33. 25	162	1. 01	------	------
1925	85. 5	84. 8	31. 59	162	. 08	------	------
1926	86. 2	82. 8	22. 04	159	1. 12	------	------
1927	90. 3	89. 1	34. 83	161	1. 85	------	------
1928	90. 2	89. 5	34. 17	162	. 11	------	------
1929	87. 6	89. 7	30. 92	158	. 07	------	------
1930	86. 6	88. 1	22. 04	141	2. 76	------	------
1931	83. 4	84. 4	8. 97	119	6. 97	------	------
1932	87. 5	87. 8	10. 33	106	6. 39	------	------
1933	81. 9	85. 9	12. 88	116	2. 58	------	------
1934	89. 5	86. 9	33. 00	124	6. 49	------	------
1935	90. 2	89. 0	30. 54	122	. 03	------	------
1936	91. 5	88. 3	33. 36	130	1. 68	------	------
1937	88. 9	87. 3	19. 51	127	2. 58	------	------
1938	93. 4	90. 8	21. 79	122	. 90	------	------
1939	90. 9	92. 1	21. 17	124	. 29	------	------
1940	91. 3	90. 2	21. 73	126	. 19	------	------
1941 [4]	94. 6	93. 1	47. 65	144	5. 58	4. 5	4. 2
1942 [4]	93. 0	89. 5	45. 61	163	7. 69	4. 7	4. 2
1943 [4]	91. 0	90. 7	52. 10	178	2. 81	4. 2	3. 8
1944 [4]	94. 4	89. 3	52. 70	186	1. 03	4. 0	3. 6
1945 [4]	93. 7	92. 0	51. 10	195	1. 33	4. 1	3. 8
1946 [4]	96. 2	90. 8	72. 00	228	7. 48	4. 6	4. 2
1947 [4]	93. 2	93. 4	85. 90	254	4. 08	4. 3	4. 0
1948 [4]	96. 7	90. 5	67. 20	255	. 98	4. 0	3. 6
1949 [4]	92. 9	93. 2	43. 40	249	1. 56	4. 1	3. 8
1950 [4]	95. 0	95. 5	86. 60	272	3. 50	4. 3	4. 1
1951 [4]	------	90. 8	69. 30	286	3. 06	4. 2	3. 8

[1] Based on the analysis discussed in this note.
[2] Index numbers, 1910–14 = 100.
[3] For formula, see Armore and Burtis (*1*, p. 9).
[4] These years omitted from analysis.

TABLE 28.—*Statistical results from an analysis of factors that affect the percentage of the cottonseed crop sold to mills.*

Correlation measurement	Variables			
	X_1X_2	X_1X_3	X_2X_3	$X_1X_2X_3$
Partial b	0. 095	−0. 38	------	------
Standard error of the b	. 030	. 18	------	------
Partial r^2	. 38	[1] 1. 21	------	------
Simple r^2	. 20	[2]	0. 42	------
R^2	------	------	------	0. 38
Standard error of estimate	------	------	------	. 016
a	------	------	------	2. 56

[1] Probability level above the 5-percent point. As this relationship is a logical one, this variable was retained in the analysis.
[2] Less than 0.005.

NOTE 11.—STEPS INVOLVED IN COMPUTING NET EFFECTS OF INCREASED YIELDS OF COTTONSEED OIL ON PRICES AND TOTAL RETURNS FROM COTTONSEED

The following example is given to indicate the exact steps involved in the use of the four equations in solving a specific problem. Assume, for instance, that there is a 10-percent increase in the yield of cottonseed oil above the 1948–50 average level and that the variables not directly affected by this change are at their average level for the crop years beginning with 1948–50 or the calendar years 1949–51, depending on the series. Background data for this period are shown in the following tabulation.

Selected market factors used in connection with relationships I, II and III: Average, crop years beginning 1948–50 or calendar years 1949–51

Item		Average
Cottonseed oil:		
Yield per ton of cottonseed crushed [1]	pound	321
Stock at factories and warehouses, January 1	million pounds	335
Cottonseed: [1]		
Production, less use for planting	1,000 ton	5,176
Sold to mills	do	4,961
Percentage sold	percent	95.8
Value of meal, hulls, and linters per ton processed	dollar	48.59
Supply per person: [2]		
Lard	pound	18.7
Other fats and oils used in food, excluding butter:		
Cottonseed oil	do	12.7
Other than cottonseed oil	do	17.5
Total	do	30.2
Disposable income per person [2]	dollar	1,339
Total population, July 1	million	152.6

[1] Year beginning August.
[2] Calendar year.

The following steps are used:

1. Yield of cottonseed oil per ton crushed—1948–50 average (321 pounds) from the above tabulation times 1.10 equals 353 pounds.

2. Production of cottonseed oil—1948–50 average sales of cottonseed to mills (4,961,000 tons) times yield of cottonseed oil per ton crushed of 353 pounds equals 1,750 million pounds.

3. Supply of cottonseed oil per capita—Production (1,750 million pounds) plus 1949–51 average stocks on January 1 (335 million pounds) divided by 1949–51 average total population on July 1, (152.6 million) equals 13.7 pounds.

4. Supply of fats and oils used in food products per capita—Supply of cottonseed oil of 13.7 pounds plus 1949–51 average per capita supply of other items (17.5 pounds) equals 31.2 pounds.

5. Wholesale price of edible fats and oils excluding butter and lard—computations based on the analysis discussed in note 5 are shown below:

a. The 1949–51 average supply of lard is 18.7 pounds per capita. The logarithm of this is 1.2718. Multiplying by the partial regression coefficient for lard of −1.110 gives −1.4117.

b. The 1949–51 average disposable income is 1,339 dollars per capita. The logarithm of this is 3.1268. Multiplying by the partial regression coefficient for income of 1.369 gives 4.2806.

c. Combining the results from steps a and b with the constant value from the regression equation of 1.3736 gives the relevant constant for this step of 4.2425.

d. The assumed supply of fats and oils used in food products per capita from step 4 is 31.2 pounds. The logarithm of this is 1.4942. Multiplying by the partial regression coefficient for this variable of −1.571 gives −2.3474. Adding the constant value from step c gives 1.8951. The antilogarithm of this is 78. This represents the index number of wholesale prices of edible fats and oils (excluding butter and lard), on a 1947–49 base, which normally would be associated with a supply of fats and oils and a disposable income of this magnitude.

6. Wholesale price of cottonseed oil—computations based on the analysis discussed in note 6 are shown below.

The final logarithm (1.8951) from step 5d is multiplied by the regression coefficient 1.135, and the constant value from the regression equation of −.9404 is added algebraically to the result. This gives 1.2105. The antilogarithm of this is 16.2 cents.

7. Value of yield of cottonseed oil per ton of seed processed—yield from step 1 (353 pounds) times price from step 6 (16.2 cents) equals $57.19.

8. Value of all products per ton of seed processed—Value of cottonseed oil of $57.19 plus the 1948–50 average value of all other products of $48.59 equals $105.78.

9. Season average price of cottonseed—computations based on the analysis discussed in note 9 are shown below:

The value from step 8 of $105.78 is multiplied by the regression coefficient 0.7424 and the constant value from the regression equation of −5.81 is added algebraically to the result. This gives $72.72. This represents the expected price received by farmers for cottonseed, assuming that margins of cottonseed processors do not change from those normally associated in the past with combined values of the products at the levels indicated (see p. 44).

10. A similar set of computations assuming no change in the yield of cottonseed oil gives a season average price of cottonseed of $71.49.

11. Percentage of crop less use for planting sold to mills—computations based on the analysis shown in note 10 are shown below:

a. The price obtained in step 9 ($72.72) is divided by the price indicated in step 10 ($71.49) and the result multiplied by 100 to give a link relative of 101.7. The logarithm of this is 2.00732. This result is multiplied by the partial regression coefficient for price of 0.09496, giving 0.1906.

b. As this analysis is based on year-to-year change, the above result can be compared with that given, assuming that there is no change in prices received by farmers for cottonseed. This would imply a link relative for price of 100 and a logarithm of 2.00000. Multiplying this by the partial regression coefficient of price (0.09496) yields 0.1899.

c. The characteristic 2 is added to the difference between the result obtained in steps a and b. This gives 2.0007. The antilogarithm of this is 100.16. Multiplying the 1948–50 average percentage sold (95.8 percent) by this equals 96.0 percent.

12. Gross income received by farmers for cottonseed—1948–50 average production of cottonseed (5,176,000 tons) times the percentage sold from step 11 (96.0 percent) times the price per ton from step 9

(72.72 dollars) equals 361 million dollars. This should be compared with the equivalent value, assuming no change in the yield of cottonseed oil.

As in step 9, this represents the income that farmers would receive, assuming that margins of cottonseed processors do not change from those normally associated in the past with combined values of the products at the levels indicated. If such margins were expected to change, an alternative computing procedure would be needed in step 9, and the results in steps 11 and 12 might be modified.

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