Volume Title: Inventories and Business Cycles, with Special Reference to Manufacturer's Inventories

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Volume Publisher: NBER

Volume ISBN: 0-870-14087-6

Volume URL: http://www.nber.org/books/abra50-1

Publication Date: 1950

Chapter Title: Ten Examples of Raw Materials Stocks

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Chapter URL: http://www.nber.org/chapters/c9133

Chapter pages in book: (p. 191 - 237)

Chapter 10

Ten Examples of Raw Materials Stocks

The sample of stocks of raw materials examined in Chapter 9 is so small and in some ways unrepresentative that interpretation and generalization was difficult. The commodities in the sample are, however, of diverse types. Much can be gained, therefore, from detailed commodity studies. This approach permits consideration also of two commodities not included in the tables of Chapter 9 because they could not be treated by the National Bureau's usual methods. We can in this way learn a good deal about how different kinds of stocks of raw materials behave and so put ourselves in a better position to speculate about the general characteristics of the class.

1 *Raw Cotton at Mills*

As argued in Chapter 9, the supply of raw materials to the manufacturers who use them can usually be quickly adjusted to the rate at which they are consumed provided one of two conditions is met. One possibility is that the materials are produced by other manufacturers or by mining industries in this country, the other that dealers or importers in this country hold a large stock. Our collection of series does not contain a single good example of the first possibility, but it does contain several cases that illustrate the second. Raw cotton is one. The essential point is to distinguish the factors governing total stocks from those governing manufacturers' stocks.

CROPS, CONSUMPTION, AND TOTAL STOCKS

The year to year changes in the crop of raw cotton are due mainly to weather conditions. Consequently, the behavior of the output of cotton is largely unrelated to business cycles. On the other hand, since the consumption of cotton in this country depends chiefly on consumers' incomes and the level of industrial activity, it tends to fluctuate together with business activity but to be relatively independent of the size of the cotton crop. The conformity indexes of the cotton crop to 18 business cycles 1867-1938 run +11, −33, −20. For 6 cycles 1914-38, the comparable indexes for cotton consumption are +67, +71, +67.[1] The relation of output and consumption may be judged from the correlation between the year to year directions of change in the two series.[2] The coefficient calculated from data extending from 1894, when the annual consumption series starts, to 1943 is negligible, less than +0.12 on a scale running from −1 to +1.

Of the two processes, production and consumption of cotton in the United States, fluctuations in the former are by far the larger. The average annual change in consumption (regardless of direction) between 1894 and 1944 was about 640 thousand bales. The average annual change in the crop was over three times as big, about 2.1 million bales. In these circumstances, one might expect

[1] This is the measure yielded when stages VIII-V are matched with business expansion. When stages I-V are used, the indexes run +100, +71, +100.

[2] This measure, which I use frequently, involves the computation of the number of instances in which (a) both series rise, (b) the first rises and the second falls, (c) the first falls and the second rises, and (d) both fall. The correlation coefficient is then given by the term

$$(ad - bc) \div \sqrt{(a+b)\,(c+d)\,(a+c)\,(b+d)}$$

This modification of the usual measure of correlation was devised by G. H. Moore and W. A. Wallis. Significance tests for this measure are described in Time Series Significance Tests Based on Signs of Differences, *Journal of the American Statistical Association,* June 1943, pp. 160 ff., and by Moore in his forthcoming book on Harvest Cycles.

The coefficient, of course, expresses the proportionate excess of the number of agreements or disagreements over the number expected on the basis of chance alone. It takes account of trend by making the number of agreements expected depend upon the proportionate distribution of rises and declines in the series studied. Compared with the National Bureau index of full cycle conformity, which is also based on directions of change, the Moore-Wallis coefficient is, in some ways, a more sensitive measure of association, in some ways, less sensitive. It is more sensitive in that it uses every change in the data whereas the National Bureau index takes account only of the change between peaks and troughs and troughs and peaks. It is less sensitive in that it counts every decline in one series matched by a rise in the other as a disagreement. The National Bureau index counts a decline in the rate of growth of one series during a contraction of the other as an agreement and the same with declines in the rate of fall of one series during expansions in the other.

movements of the total stock of cotton to be dominated by the shifting size of the crop and to behave during business cycles in much the same irregular fashion as the crop itself.

This might well be so were it not for exports. Foreign sales have usually taken well over half the United States cotton crop. Moreover, exports have tended to vary directly with the size of the crop. The correlation between the directions of change in the crop and exports, 1866-1942, is +.60. Apparently when the United States crop is large, the price of cotton tends to be depressed and more American cotton tends to be sold abroad for consumption and stock piling, reducing fluctuations in the supply of cotton remaining in this country. Annual fluctuations in the addition to United States supply after allowing for exports was only some 1.5 million bales, 1894-1944. The residual supply is subject to more violent changes than is consumption but the difference is not as large as that between the crop and consumption.

These considerations enable us to define certain expectations concerning the behavior of the total stocks of cotton during crop cycles on the one hand and during consumption and business cycles on the other. If consumption did not fluctuate during crop cycles, we would expect a year of good crops to be a year of large stocks. Although exports would take some of the surplus, a larger part would still remain to be absorbed into the United States stock pile. There should, however, be some tendency for the peaks and troughs of stocks to lag behind the turns of crop cycles and sometimes to skip cycles. For when crops decline after the peak year of a crop cycle, the new supply of cotton, after allowing for exports, may or may not fall below consumption. If it does, stocks will decline synchronously with the crop. If not, stocks will rise during the first year of smaller crops. If the crop declines a second year, the residual supply is likely to be deficient compared with consumption and stocks will decline; but the peak of the stock cycle will have come a year after the peak of the crop cycle. If favorable weather brings a larger instead of a smaller crop the second year, then—still on the assumption that consumption remains constant—stocks will not fall at all during that crop cycle. The decline of the crop would be matched by a decrease in the rate of growth but not by an absolute reduction of stocks.

These expectations, however, represent only a general tendency. Consumption does not remain constant during crop cycles; it fluctuates irregularly. In addition, changes in exports may sometimes completely offset changes in crops. True, changes in domestic supply, even after allowing for exports, are typically larger than those in consumption. Nevertheless, one would not expect aggregate stocks to conform perfectly to crop cycles.

Our expectations about the relation between total cotton stocks and consumption are symmetrical with, but opposite to, those we hold about stocks and crops. Thus if harvests were of constant size, we would expect stocks to vary inversely to consumption (and to business cycles, too, since consumption rises and falls with business activity). We would expect the peaks of stock cycles, however, to lag behind the troughs of consumption cycles since consumption will not begin to outrun production until consumption has recovered to a certain extent.[3] Similarly, we would expect the troughs of stocks to lag behind the peaks of consumption. This expectation, however, would hardly be fulfilled in every cycle since harvests vary widely and erratically.

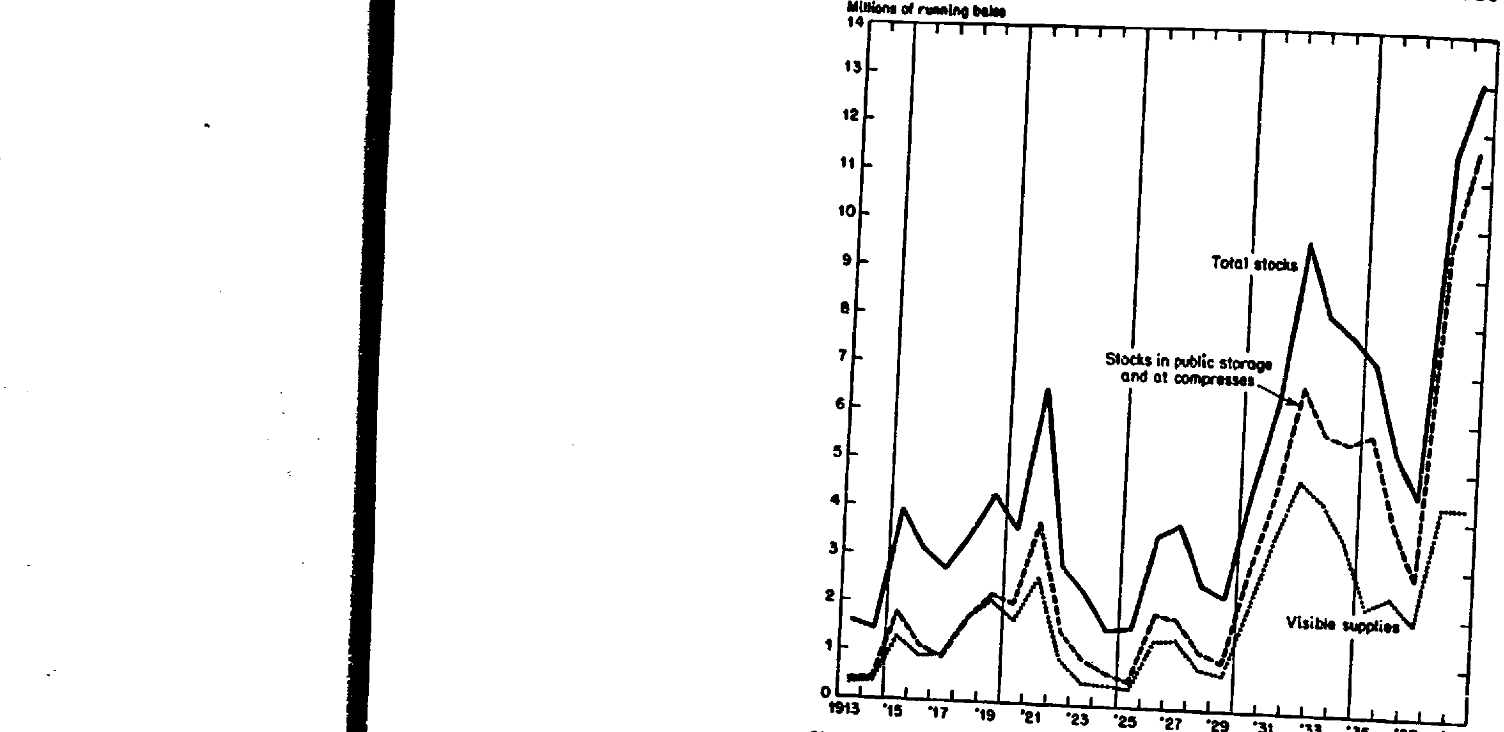
The cyclical movements of total stocks accord in general with these hypotheses. Statistical confirmation, however, rests on data that are not wholly satisfactory. Estimates of total stocks of cotton in this country begin in 1913, but they are only for ends of crop years. Fortunately, two monthly series that are fair indicators of the total are available: stocks at public warehouses and compresses, compiled by the Bureau of the Census since 1912, and 'visible supplies' reported by leading financial journals and organized by the National Bureau into a continuous series running back to 1870 (Chart 16).[4]

At least at the ends of crop years, when the crop has been almost entirely marketed, stocks at public warehouses are apparently good indicators of the movements of total stocks, and visible

[3] These statements imply seasonally corrected observations at monthly intervals such as are available for consumption and stocks.

[4] Visible supplies are the stocks held at principal warehouses. The cotton in question is, therefore, in the same position as that reported by the census for stocks at warehouses, but the coverage of the visible supplies series is smaller. Monthly estimates of total stocks are provided by the New York Cotton Exchange only since 1926.

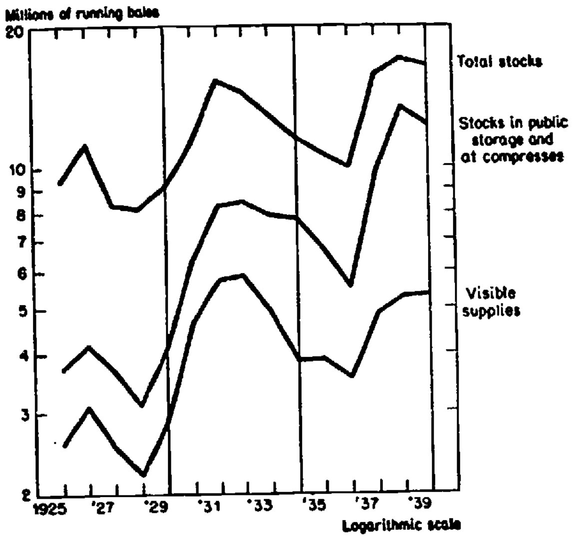
Chart 16
Raw Cotton Stocks, End of Crop Year, July 31, 1913–1939



supplies are good indicators of both. The situation must obviously be less satisfactory as one moves back from the end of the crop year to its beginning when a larger portion of the stock is still held on farms, but the difference can hardly be large. The cotton crop, which begins to be picked heavily in August, is almost entirely harvested by the end of December. By that time over 75 percent of it has usually been sold and moved from farms to warehouses. By the end of February the marketed portion usually exceeds 85 percent. Not all the stock owned by farmers, moreover, remains on the farm until it is sold. Hence the portion of the stock transferred to public warehouses is probably larger on any given date than the portion marketed by farmers. I therefore accept data for visible supplies or stocks at warehouses as fair indicators of the movements of total stocks. Crop year averages indicate the general similarity of the three series since 1925 (Chart 17).[5]

[5] Comparisons based on annual averages are not available earlier since total

Chart 17
Raw Cotton Stocks
Average Monthly Standings during Crop Years



For comparisons with crop fluctuations, I use the visible supplies series because it extends back to 1870. Stocks tend to conform positively to crop cycles. The conformity indexes for crop year averages of stocks for 20 crop cycles 1870-1939 run +60, +33, +45. Some tendency for stocks to lag behind crops is indicated by the higher indexes yielded by observation of averages of stocks for calendar years beginning six months after the beginning of each crop year: +70, +80, +69.

During cotton consumption cycles our expectation is that stocks will vary inversely with a lag. Monthly consumption data since 1912 make it possible to mark the boundaries of consumption cycles by months rather than years. Since that date, too, census records of stocks in public warehouses and at compresses are available. I calculate the conformity of total cotton stocks to consumption cycles by measuring the movements of stocks in public storage during cycles bounded by monthly troughs and peaks in consumption. Evidence that stocks tend to vary inversely is provided by con-

stocks are not estimated before the middle of 1925 except for ends of crop years. These figures overstate the differences between total stocks and the other two series, since they credit the unpicked portion of the crop to stocks on farms and, therefore, to the total as of the beginning of the harvest season.

formity indexes that run −25, −33, −50 when stages V-II are matched with expansion. This pattern, which indicates that stocks typically do not begin to decline until one stage after consumption has begun to rise, gives some hint that, in accordance with expectations, the turns of stocks come later than the (opposite) turns of consumption, at least at consumption troughs. Better evidence is afforded by direct comparison between the peaks and troughs of consumption and the opposite turns of stocks. Six comparisons could be made at both upper and lower turning points. The trough of stocks lagged behind the peak of consumption on three occasions: it fell in the same month once and led twice. At consumption troughs, the peak of stocks lagged five times and turned in the same month once. The average lag of stocks at consumption peaks was 0.7 months; at consumption troughs, 11.8 months.

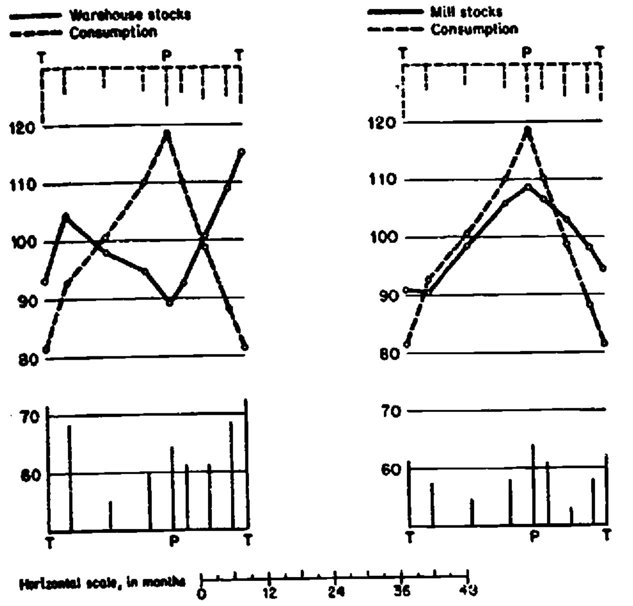
TOTAL STOCKS AND MANUFACTURERS' STOCKS

The large and irregular fluctuations of the cotton crop during cycles of business and cotton consumption cause warehouse stocks of cotton—and I think total stocks as well—to vary inversely to cotton consumption. The behavior of stocks of raw cotton at textile mills is in striking contrast (Chart 18). Mill stocks move up and down together with consumption. The conformity indexes of mill stocks during 8 consumption cycles 1913-38 were +50, +56, +62. Mill stocks tend to lag behind consumption, but by only a short interval. Of eight comparisons at peaks, stocks lagged five times; the average lag was 1.5 months. Of seven comparisons at troughs, stocks lagged six times and turned synchronously with consumption once; the average lag was 5.1 months.

The reason for the contrasting behavior of mill and warehouse stocks is readily found. If manufacturers held the bulk of the cotton stock, their holdings would necessarily reflect the uncoordinated fluctuations of crops and consumption. Allowing for a lag, their stocks would tend to rise and fall with the crop during crop cycles and to trace inverted patterns during consumption cycles. But manufacturers are not the chief holders of cotton. Average stocks at mills were only 11 percent of total stocks between 1926 and 1939.[6] Between manufacturers' consumption and the current

[6] This estimate, computed for the period during which monthly figures for

Chart 18
Raw Cotton Stocks and Consumption
Average Patterns during 8 Consumption Cycles, 1914-1938



crop stand the large buffer stocks in warehouses which afford the mills an ample and flexible source of supply. Cotton textile manufacturers, therefore, are in a position to obtain raw materials and to keep stocks at their mills in quantities appropriate to the rate at which they are converting cotton into yarn. Consequently, they keep larger quantities at mills when business is good and reduce their holdings when business contracts.

2 *Raw Silk at Manufacturers*

Raw silk at American silk mills presents a situation not unlike raw cotton. The output of silk, depending as it does upon the breeding of silkworms, responds slowly to changes in current demand.[7]

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total stocks are available, probably understates the importance of mill stocks before 1926. With the onset of the great depression cotton stocks rose to very high levels and the surplus naturally remained in public warehouses. But it is unlikely that mill stocks were more than 20 percent of the total for any long period in earlier decades.

[7] In this respect, the supply of silk is like that of other animal products rather than like crops, which vary in response to weather conditions.

Moreover, the necessity of transporting the silk from Japan injects several more months between the time American importers place their orders and the time the goods arrive in this country. Only minor portions of the supply come from countries other than Japan.

If American mills held the bulk of the silk stock, one would expect that the combination of a variable demand with a laggard supply would cause stocks to vary inversely to silk consumption, with a lag. Since, however, the bulk of all silk stocks are held at warehouses in this country and in Japan, silk fabricators can keep a supply at their mills that varies with their activity.

The relative sizes of the various segments of total silk stocks are suggested by the fact that during 1925-33 silk at Japanese ports, in transit to the United States, and in United States warehouses ran about four times as large as monthly silk deliveries to American mills, while stocks at mills came to slightly more than half a month's supply. Warehouse stocks in the United States alone averaged somewhat larger than a month's supply.

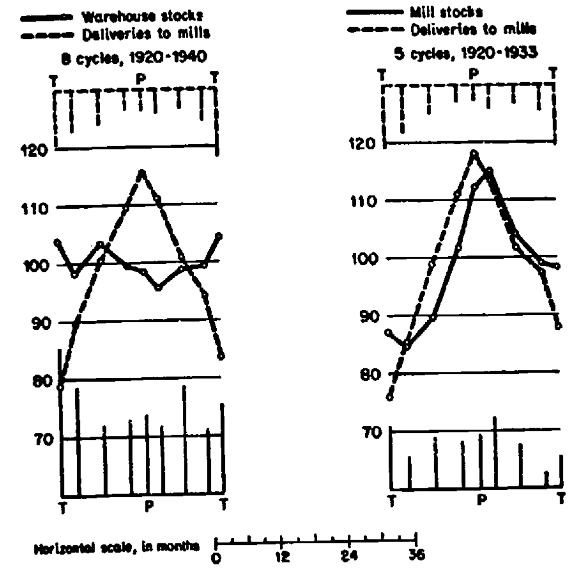
United States warehouse stocks, as distinct from mill stocks, share with stocks in Japan the burden of absorbing maladjustments between supply and demand, and they may be affected also significantly by price speculation. In any case, they do not appear to fluctuate regularly either with imports of silk or with deliveries of silk to mills. The conformity indexes of warehouse stocks to cycles of imports during two cycles 1921-34 were +33, 0, 0. During 8 cycles 1920-40 the conformity indexes of warehouse stocks to cycles of deliveries to mills were +25, −25, −7.

In contrast, the relation between stocks at mills and the rate of consumption of raw silk, as measured by deliveries to mills, is apparently fairly close. For 5 cycles in deliveries 1920-33, conformity measures of stocks to deliveries run +100, +20, +78 when stages II-VI are matched with expansions in deliveries (Chart 19). When stages I-V are matched with expansions, the indexes become +100, +20, +100.

3 *Raw Cattle Hides in Tanners' Hands*

Like other commodities reviewed in this chapter, cattle hides are supplied under conditions that make difficult a prompt adjust-

Chart 19
Raw Silk Stocks and Deliveries to Mills
Average Patterns during Deliveries Cycles



ment of supply to demand in an over-all sense. As in the cases of cotton and silk, however, stocks held by dealers make it possible for processors to get their raw materials as they require them and to maintain a stock fairly well adjusted to their rate of activity.[8]

Raw hides are a byproduct of cattle slaughtering. Since only some 10 percent of the value of an animal is derived from its hide, the rate of slaughtering is dominated by the supply of cattle and the demand for meat rather than by the supply of cattle and the demand for hides. Nevertheless, the rate of cattle slaughter (as represented by the number of cattle slaughtered under federal inspection) is not uncorrelated with the rate at which cattle hides are processed (represented by cattle hide 'wettings'). For 4 cycles 1923-42 conformity indexes of cattle slaughter to wettings cycles run +50, 0, +43.

This degree of correlation probably arises from the fact that the demand for shoes, which controls the rate at which hides are processed, and the demand for beef, which strongly influences the rate

[8] In her forthcoming book, *Consumption and Business Cycles—A Case Study: Footwear*, Ruth P. Mack will examine in detail the relations between hide supply and leather production, including the behavior of hide stocks.

of cattle slaughter, are both affected by fluctuations in consumers' incomes. In view of the indirect nature of the relation, it is not surprising that the cyclical patterns of the two series do not resemble each other closely (Chart 20).[9] Although these patterns show relatives on different cycle bases they suggest that at peaks in cycles of hide processing, the consumption of hides outruns the domestic supply. On the other hand, at troughs in cycles of hide consumption, the rate of slaughtering outruns the rate at which hides are processed. The two processes are responding to different stimuli.

The major parts of the differences between the rates at which hides are produced and consumed in the United States are offset by fluctuations in imports of hides. Between 1921 and 1939 imports accounted on the average for about 15 percent of the total movement of hides into sight. Imports, however, are subject to wide fluctuations. When hides in this country are scarce relative to demand, the price rises and it becomes profitable to import. When consumption of hides declines relative to domestic supply, the price falls, and importing becomes unprofitable (Chart 21).

Among the 19 year to year movements in Chart 21 there are only two disagreements between the directions of change in the two series. For one, that from 1933 to 1934, the explanation is obvious. The 1934 drought forced the slaughter of an extraordinarily large number of animals. Imports, of course, in the volume of 1933 were unnecessary, but the domestic price was maintained by the government's drought relief program.

As a result of the counterweight provided by imports, cattle hides move into sight at a rate fairly similar to that at which cattle hides are processed.[10] The conformity indexes measuring the fluctuations of movement into sight during 3 cycles of wettings 1923-37 run +33, +100, +33 (Chart 22). The patterns of the two series resemble each other far more closely than did domestic slaughter and wettings (Chart 20). The flow of imports helps make up for the insensitivity of domestic cattle slaughter to cycles in cattle hide

[9] The chart shows the movement during an initial contraction and a terminal expansion as well as the three full cycles between 1926 and 1937.

[10] Movement into sight includes hides from federally inspected slaughter, tanners' receipts of hides from uninspected slaughter, and imports.

Chart 20
Cattle Slaughter and Hide Wettings
Patterns during Wettings Cycles

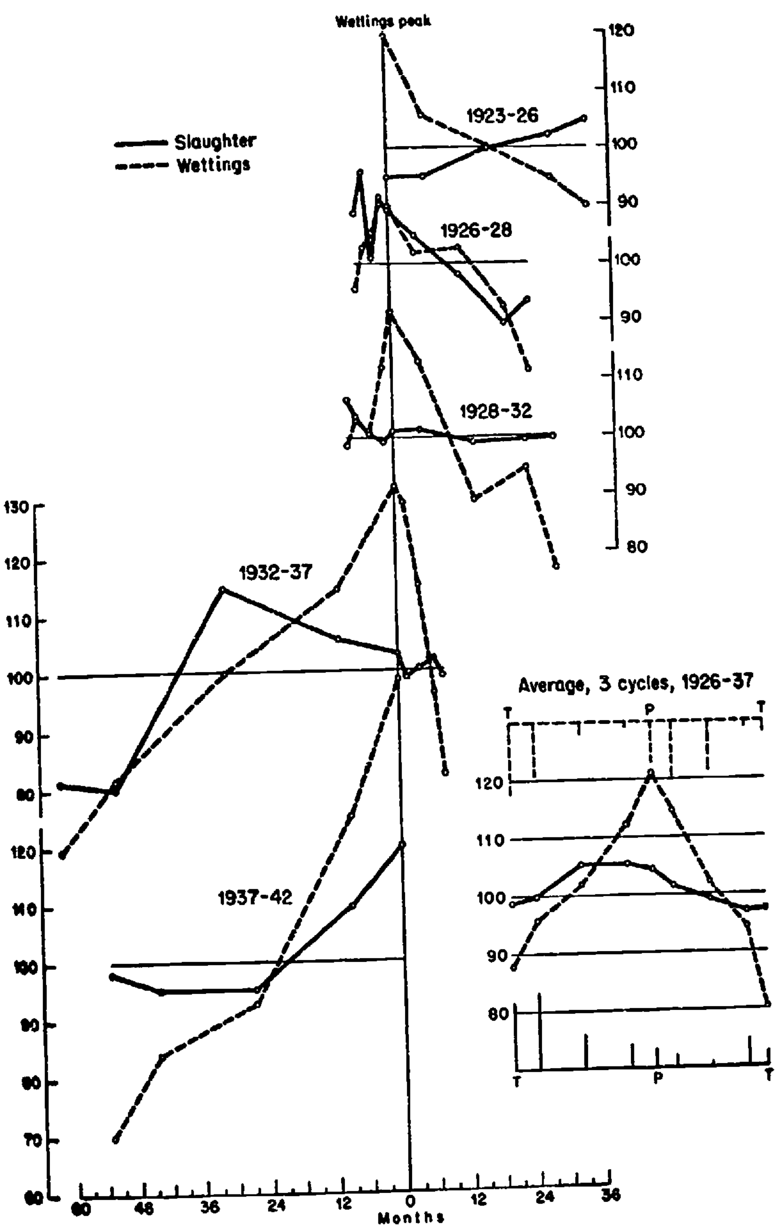
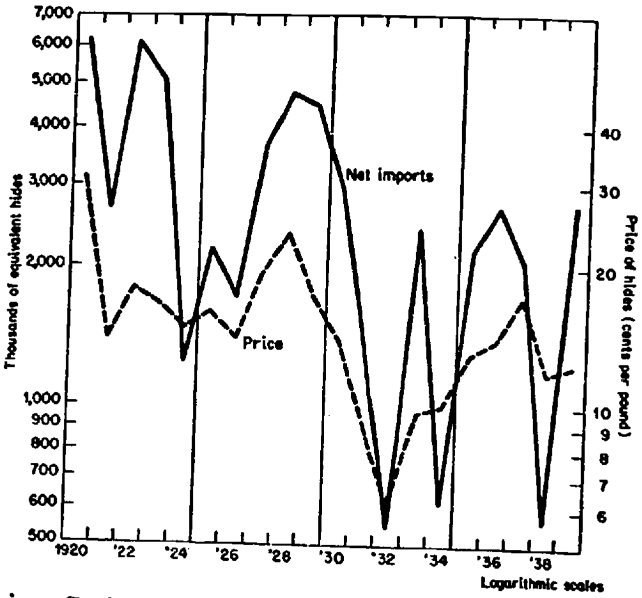


Chart 21
Cattle Hides: Net Imports and Wholesale Prices

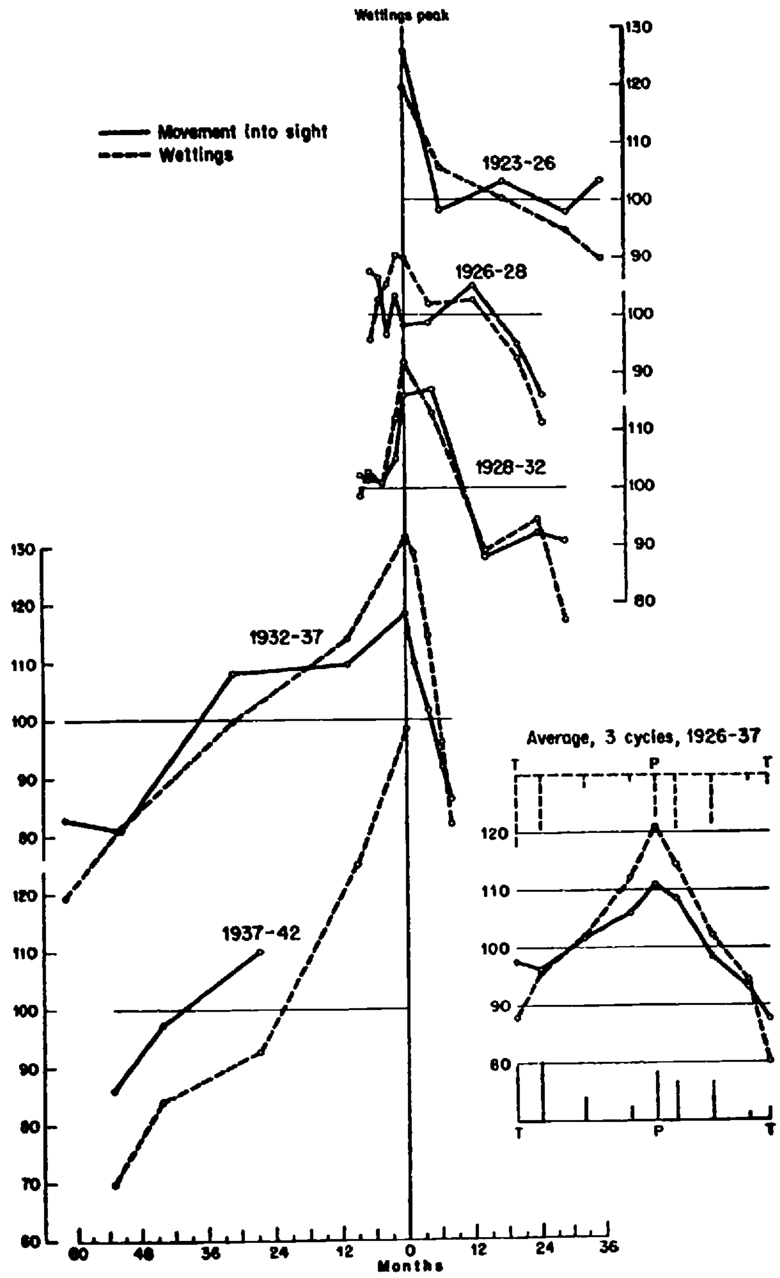


processing. Cycles in wettings have a wider amplitude than total hide supply (judged by movement into sight) in the same periods, although the difference is far less than that between wettings and domestic slaughter. The relative insensitivity of supply, therefore, leaves its mark on the cyclical fluctuations in stocks.

The data on stocks of raw cattle hides show stocks held by two major groups of businessmen: on the one hand, packers and butchers who produce the raw hides and dealers and importers who import and assemble domestic hides (especially from slaughterers other than the large packing houses), and, on the other hand, tanners who process the hides. Dealers, importers and packers have held about 40 percent of total stocks, tanners about 60 percent.

The relative sluggishness of total supply affects total stocks of raw hides much as supply affected total stocks of cotton. Since the rate of fabrication of hides tends to outrun the supply near the peaks of leather tanning (wettings) cycles, and since the reverse tends to be true near their troughs, we may expect hide stocks to begin to fall before the peak in the wettings cycle and to begin to rise before the trough. This is, in fact, what the figures show. When we match stages VII-III with expansions, that is, if we assume a

Chart 22
Cattle Hides: Movement into Sight and Wettings Patterns during Wettings Cycles



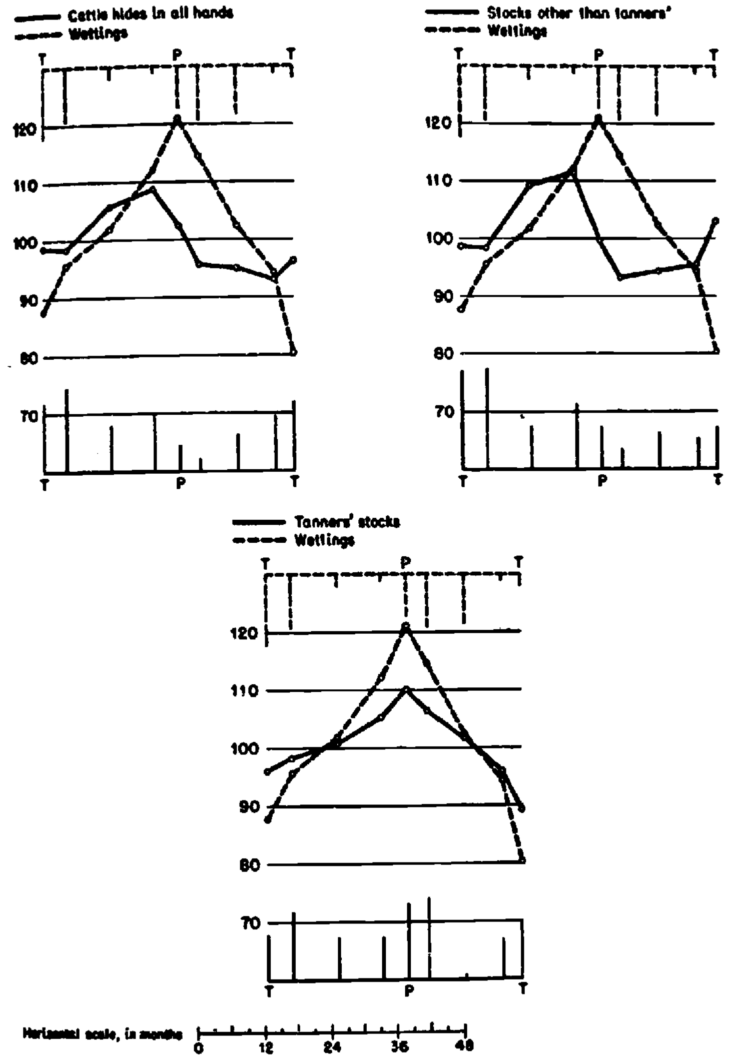
long lead, the conformity of hide stocks in all hands to wettings cycles is +50, +33, +67 for 3.5 cycles 1926-42. Such positive conformity with a long lead is, of course, equivalent to inverted conformity with a lag. We may, therefore, describe the behavior of total hide stocks in the terms we applied to total cotton stocks, that is, as conforming to consumption cycles inversely with a lag.[11]

This feature of hide stocks is due to the combination of dissimilar behavior that characterizes tanners' stocks, and stocks held by others. The tendency for stocks to turn before the peaks and troughs in wettings is wholly concentrated in the stocks held by dealers, importers and packers. The pattern of total stocks thus appears in exaggerated form in the holdings of the packers and middlemen. When stages VII-III are matched with expansions, the conformity indexes of dealers', importers' and packers' stocks to the 3.5 cycles of wettings 1926-42 run +50, +33, +100. Apparently, therefore, it is these stocks that absorb the discrepancies between the consumption of hides in leather tanning and the somewhat insensitive reactions of supply. Using the buffer supplied by the packers and middlemen, tanners, in contrast, can increase their holdings of raw materials when their rate of activity rises and liquidate their stocks of raw hides when their needs decline. The conformity of this class of stocks to wettings cycles is best measured synchronously; the indexes run +50, +50, +71 for 4 cycles 1923-42. Chart 23 compares the patterns of the three classes of stocks with each other and with cycles of wettings. As noted in Chapter 9 (Table 44), tanners' stocks show some slight tendency to lag behind the turns of wettings.[12]

[11] As explained in Chapter 3, series that typically rise between stages VII and III of reference cycles are arbitrarily treated as positive by the National Bureau. In measuring conformity, the series' typical periods of rise, between stages VII and III, are matched with reference expansions, and the resulting conformity indexes have plus signs. But since stages VII and III are the midpoints of reference contractions and expansions respectively, a series that typically rises between these stages may logically be treated as inverted. If that were done, its typical periods of rise would be matched with reference contractions, its conformity indexes would be unchanged, but they would have minus signs.

[12] No indication of this tendency appears in Chart 23. But reference cycle patterns often fail to reflect short lags, even if they occur regularly, because the stage interval is a rough unit covering several months.

Chart 23
Cattle Hide Stocks and Wettings
Average Patterns during 3 Wettings Cycles, 1926-1937



4 *Crude Rubber Stocks*

United States stocks of crude rubber have several interesting features in common with the commodities reviewed above, especially with silk, and one crucial difference. Like silk, rubber is the product of tree culture, is produced largely in the Far East, and must travel a long way to reach this country. The salient difference lies in the distribution of stocks. A much larger portion of world stocks of rubber than of silk is held by American interests. During 1927-37 United States firms owned some 58 percent of world stocks as judged by an average of year end figures. More important, United States rubber stocks, as we shall see below, are largely held by manufacturers of rubber products. The buffer of dealers' stocks enjoyed by manufacturers of cotton, silk, and hides seems to play less of a role.

INVERTED CONFORMITY OF UNITED STATES STOCKS TO RUBBER CONSUMPTION CYCLES

Rubber stocks are represented by a series that combines total crude rubber inventories in the United States with stocks in transit to this country. Because stocks are largely concentrated in the hands of manufacturers, I treat this series also as representative of manufacturers' holdings.

No proper monthly index of rubber consumption by manufacturers was available to me at the time of this investigation. But since the production of automobile tires and tubes has accounted for about two-thirds of the rubber used in this country during the period covered by the stocks data, that is, since the early 'twenties, I use automobile tire production to represent rubber consumption (Chart 24).

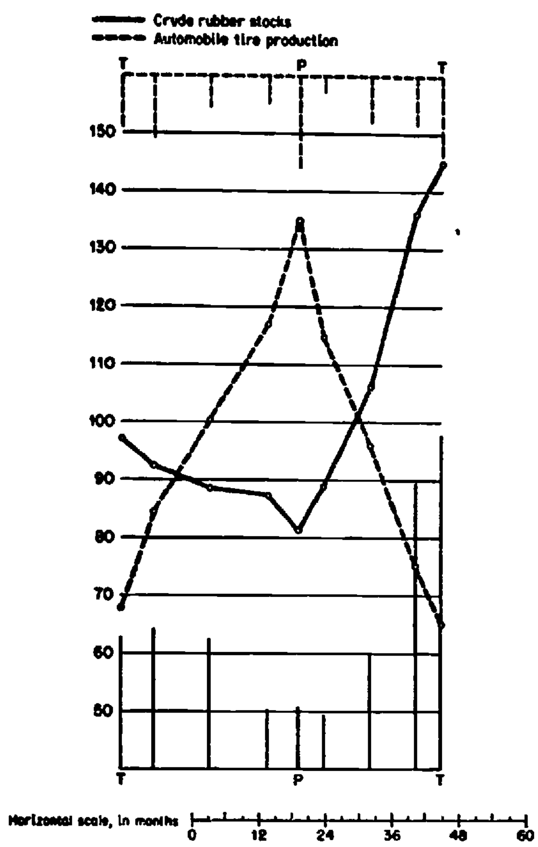
The suggestion of inverted conformity given by the average cycle pattern of United States rubber stocks during 3 consumption cycles 1923-38 is confirmed by conformity indexes that run 0, —50, —71 for 4 cycles 1923-41.[13] The indicated lack of conformity to expansions in this inverted series is due to the marked upward trend of stocks.

CAUSES OF INVERTED CONFORMITY

The inverse correlation between United States stocks and consumption is due to a combination of several factors inherent in the market in which rubber is sold and conditions affecting its production. As already indicated, the consumption of rubber in this country has been dominated, since the use of automobiles became wide-

[13] The conformity measure includes an extra half cycle at both the beginning and the end of the series.

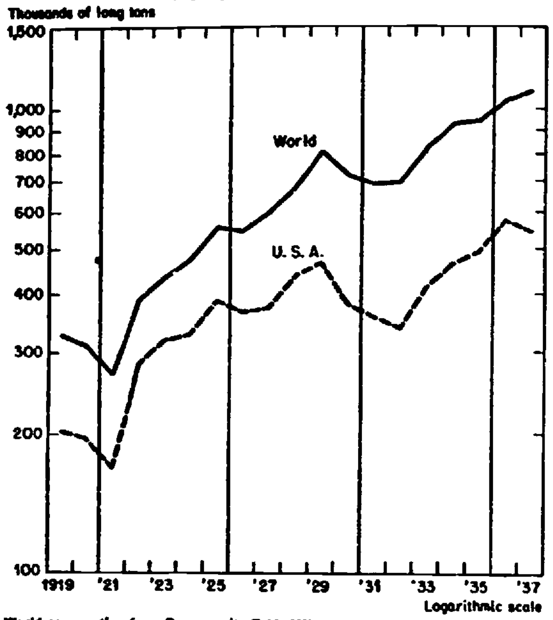
Chart 24
Crude Rubber Stocks in and afloat for the United States and Automobile Tire Production
Average Patterns during 3 Production Cycles, 1923-1938



spread, by the production of rubber tires and tubes. As automobile production has fluctuated violently in response to changes in general business conditions and in consumer incomes, so, too, has the consumption of rubber in the United States. And as these changes in United States consumption were large relative to the world use of rubber, fluctuations in American consumption have tended to control changes in world consumption (Chart 25).

Were it not for governmental regulation or cooperative action among producers the industry's ability to adjust output to changes in demand would be extremely limited. The rubber industry shares with most others an inability to reduce productive capacity

Chart 25
Crude Rubber Consumption
World and United States



World consumption from Rae, op. cit., Table VII.

U. S. consumption from *Survey of Current Business*, 1942 Supplement, p. 160. Estimates of Department of Commerce and Rubber Manufacturers Association.

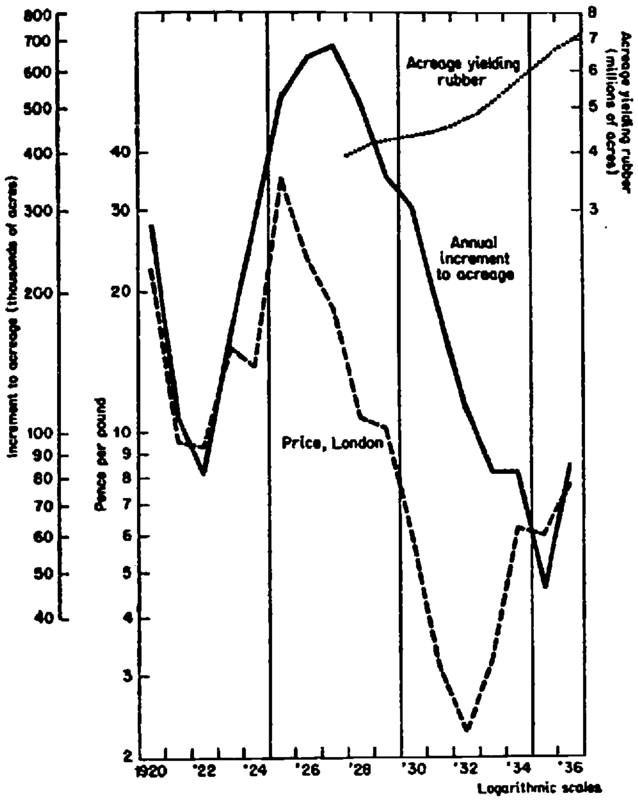
rapidly. In rubber, indeed, productive capacity increases for some years if not utilized, for rubber trees benefit from rest. The industry differs from other industries, however, in the length of the period required to bring additional capacity into being. A young rubber tree cannot profitably be tapped until it is 5 or 6 years old, and does not yield its maximum until it is 10 years old. However, once a tree is planted, the cost of bringing it to the age of profitable yield is very low. Thus, increments to productive capacity may be large in years when demand is low and falling, as they were in 1920-22 and again in 1929-32.[14]

The acreage planted in rubber in a given year varies with the price of rubber, apparently with some lag (Chart 26). Thus the price of rubber reached a peak in 1925, while the annual increment to acreage reached a maximum in 1927 and remained high

[14] Cf. George Rae, Statistics of the Rubber Industry, *Journal of the Royal Statistical Society*, New Series, CI, Part II, 1938. Much of the information in this section is drawn from this excellent source.

Chart 26

Capacity of Rubber Industry and Price of Crude Rubber



Annual increment to acreage and prices from Rae, op. cit., Table II. To estimate acreage yielding rubber, 1927-36, annual increments to planted acreage were added to the acreage yielding in 1927 allowing for an 8-year lag between planting and maturity.

for some years. Since five years must pass before trees begin yielding and ten years for the yields to reach their peak, the additions to effective productive capacity were considerable in 1929-32 when demand fell sharply. If we assume that new trees produce an average yield in eight years, it may be estimated that between 1929 and 1931, when consumption of rubber fell 14 percent, productive capacity increased some 6 percent. Hence to reduce output by an amount equal to the decline of consumption would have required a reduction of perhaps 20 percent in the intensity with which the acreage available was worked.

There are great difficulties, however, to reducing the output from mature acreage. Direct expense is low relative to total cost and the industry is competitive. For native producers, who contribute about 40 percent of the total supply, direct costs hardly exceed the expense of bringing the product to market. And by sacrificing the yield of future years, i.e., by overtapping, present output can be augmented at little extra cost—an expedient to which hard-pressed companies are forced when business is poor.[15] As a result, output fell only 6 percent between 1929 and 1931. Even by 1932 the cut in output relative to 1929 did not exceed 14 percent.

Once production has been curtailed, it cannot be increased rapidly, even when mature tree acreage is available, for it is difficult to assemble an adequate labor force after the workers have scattered, often to distant places. In the depression of 1929-32 surplus labor in Malaya and Sumatra was repatriated to India and Java.

To help overcome these difficulties of adjusting output to demand, the British and Dutch governments, who controlled the rubber producing areas before the war, imposed quota restrictions on the exports of individual producers. Two plans have operated with some degree of effectiveness. The Stevenson Scheme, in force from November 1, 1922 to October 31, 1928, controlled exports only from British possessions and from British estates in the Netherlands Indies by means of an export duty. Exports in excess of quotas, which varied with the price of rubber, were subject to a prohibitive tax. The International Rubber Regulation Scheme, in force from May 1934 until the outbreak of the war, regulated exports of both British and Netherlands possessions. Under it export quotas were assigned directly to individual producers, except native producers in the Netherlands East Indies whose output was controlled by an export tax until January 1, 1937.

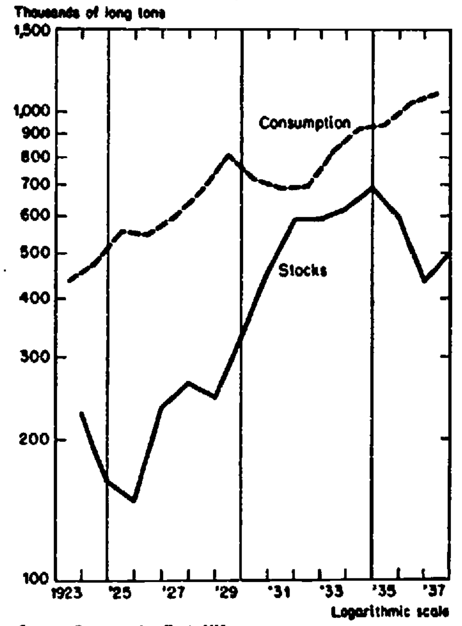
Both schemes influenced output by regulating the quantity growers might export. Both probably kept exports from increasing as rapidly as they might otherwise have done during the dominantly prosperous periods in which they were effective. Under the International Rubber Regulation Scheme, world stocks fell some 37 percent from 1934 to 1936. It is doubtful, however, that such devices can operate with sufficient flexibility and speed to prevent

[15] Ibid., pp. 324-6.

a substantial increase of stocks when consumption drops rapidly. When American consumption declined in the 1937-38 contraction, world stocks rose 42 percent (between May 1937 and April 1938).[18]

We have now seen that cycles in American consumption cause marked fluctuations in the total absorption of rubber, and that rapid adjustments of output to demand are prevented by the conditions under which the product is grown and sold. Since rubber deteriorates if stored for a considerable period in the East, only stocks in transit to ports and awaiting shipment are held in producing countries. Exports, in consequence, vary with output, and stocks outside the producing areas absorb the discrepancies between consumption and an output not easily controlled. The tendency for total stocks to move inversely to world consumption, after allowing for the marked upward trend in both series, is illustrated in Chart 27.

Chart 27
Crude Rubber: World Consumption and Stocks outside Regulated Areas

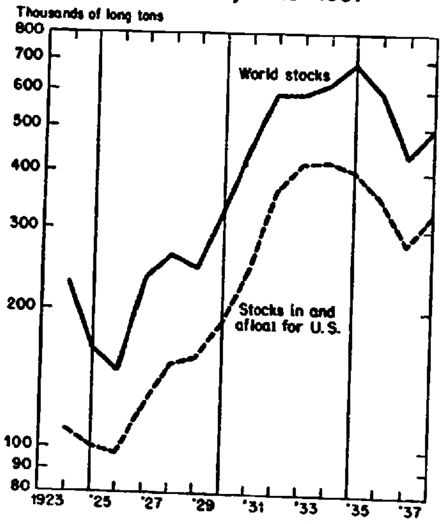


Source: Rae, op. cit., Table XV.

[18] Cf. Rae's description of the administrative problems involved in the operation of the scheme, op. cit., p. 355.

Finally, just as there is a close relation between United States and total consumption (the causal chain running from the former to the latter) so there is a close relation between United States stocks and world stocks (the causal chain running from the latter to the former) (Chart 28). The large rubber manufacturers of the United States are such big factors in the total market for rubber, and more especially in that for surplus rubber, that the absorption of unconsumed output would probably cause precipitous declines in price unless they were willing to take large portions of the excess supply.[17] Their ability to finance such holdings and their interest in the market makes such action natural.

Chart 28
Crude Rubber: World Stocks and Stocks in and afloat for the United States End of Year, 1923-1937



World stocks from Rae, op. cit., Table XV.

[17] Rae writes (op. cit., p. 331): "It seems likely that the majority of small and medium sized factories do not carry much more than their necessary working stocks. The large manufacturers, probably because of their greater commitments, must look further ahead and carry considerable stocks in addition to varying quantities of forward purchases. It would seem, therefore, that a great part of the rubber surplus to the necessary manufacturing requirements is in the hands of the larger manufacturers. The four big American manufacturers and one big British manufacturer are believed to account, between them, for nearly half the world absorption, although the buying of crude rubber by these five companies is competitive."

In short, the inverse correlation between manufacturers' stocks and consumption in the United States stems from the fact that the principal American manufacturers must themselves largely absorb the discrepancies between consumption and output that arise because of the sharp fluctuations in consumption and the sluggish response of production.

5 *Cottonseed at Oil Mills*

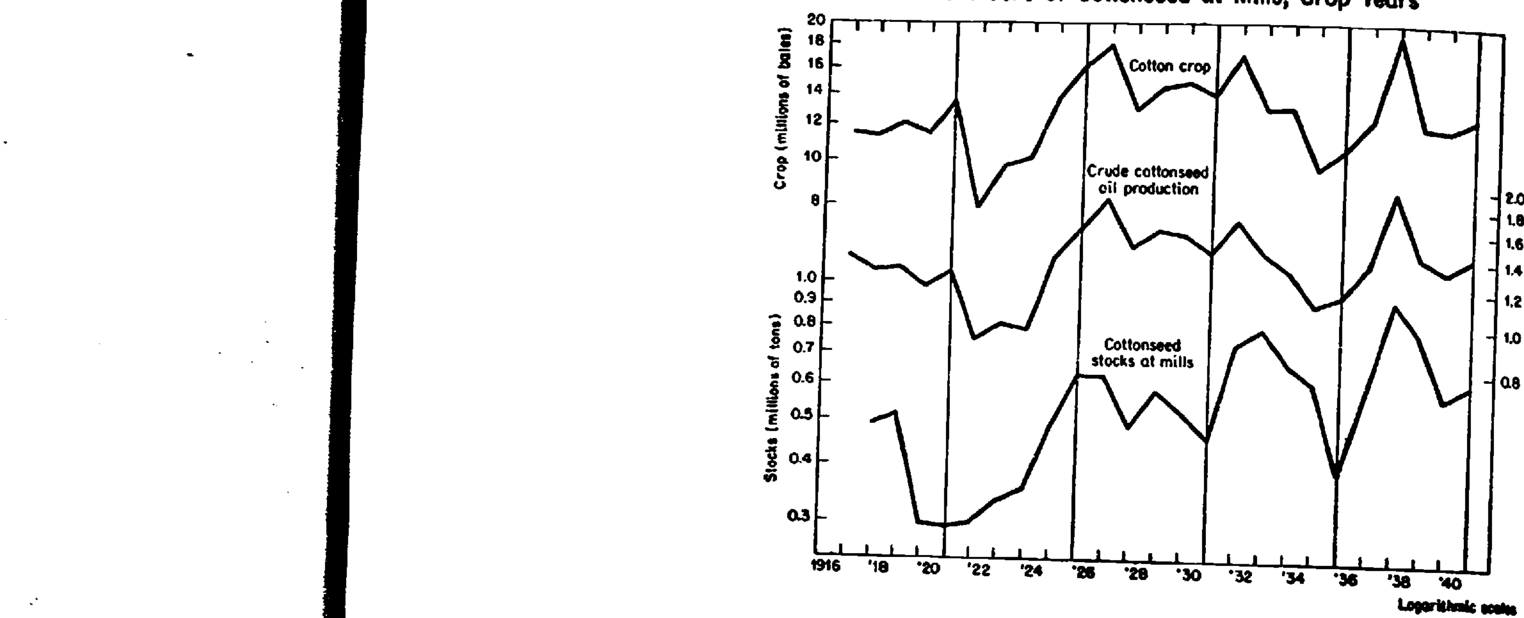
In the above examples, we found that raw materials stocks held by manufacturers tended to move together with the consumption of materials when there was a buffer stock to absorb the difference between supply and consumption. We would expect the same result when the output of the material can be adjusted rapidly to changes in demand. Cottonseed held by crushing mills is a case of a somewhat different sort. Again stocks held by fabricators move together with manufacturing activity, but this time for different reasons. Manufacturers keep a stock of raw materials that rises and falls with their output not because the supply of raw materials can be adjusted to the rate at which it is consumed, but because fluctuations in the rate of fabrication are dominated by conditions of raw material supply.

The movements in the size of the cotton crop closely resemble those in the production of crude cottonseed oil (Chart 29). Since short-term fluctuations in the cotton crop are influenced largely by the weather, this close resemblance must be due to the stimulus given by a large and cheap supply of seed.

Cottonseed, cheap and bulky, is less expensive to store after being pressed into oil. When the cotton crop is big, farmers and ginners sell large quantities of seed to avoid the cost of storage, and the crushers promptly convert the seed to oil. A larger than normal crop means that crushers hold a larger than normal stock of seed during the harvesting season and produce a larger than normal quantity of oil during the ensuing year.[18] These observations are

[18] "The bulk of a cottonseed crop is marketed within the months of September, October and November, when two-thirds of a season's crush is normally bought by the mills. From the beginning of the season, August, to the end of December, the mills must buy and receive from 80 to 85 percent of the crop, for generally neither the farmers nor the ginners are properly equipped to store and care for the seed. The cost of warehousing is a necessary and sizable expense

Chart 29
Cotton Crop, Crude Cottonseed Oil Production, and Stocks of Cottonseed at Mills, Crop Years

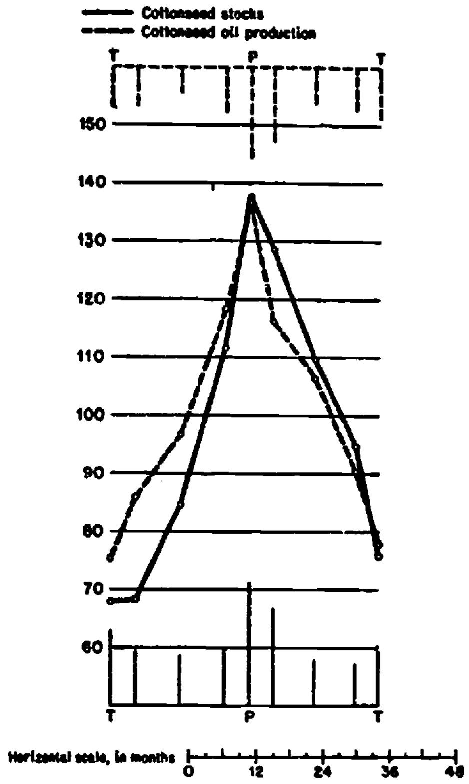


illustrated in Chart 29 by annual data and confirmed by measures made from monthly data. The National Bureau index of cottonseed stocks conformed perfectly to 5 cycles in oil production 1920-40. The high degree of similarity in the average cycle patterns in Chart 30 are consistent with the explanation given above.

A word about the probable relation of this stock to business cycles is now in order. In the cases of the other commodities studied in this chapter, the rate of consumption of the raw material is governed largely by influences from the side of demand. Cotton consumption, for example, depends largely upon the demand for cotton goods, and fluctuates with business activity. Thus to state the relation between raw cotton stocks at mills and cotton consumption is also to state, at least approximately, their relation to business cycles. In the present instance, however, this is not true. Cottonseed oil production, as we have just seen, rises and falls with the availability of its raw material rather than with demand. And

connected with handling cottonseed, and this tends to force the products on the markets regardless of current demand." *Cottonseed and Its Products*, National Cottonseed Products Association, Feb. 1937, pp. 20-1.

Chart 30
Cottonseed Stocks at Mills and Crude Cottonseed Oil Production
Average Patterns during 5 Production Cycles, 1920-1940



since the supply of cottonseed is controlled entirely by the size of crops, it can hardly have regular relation to business cycles.[19]

6 *Raw Sugar Stocks at Refineries*

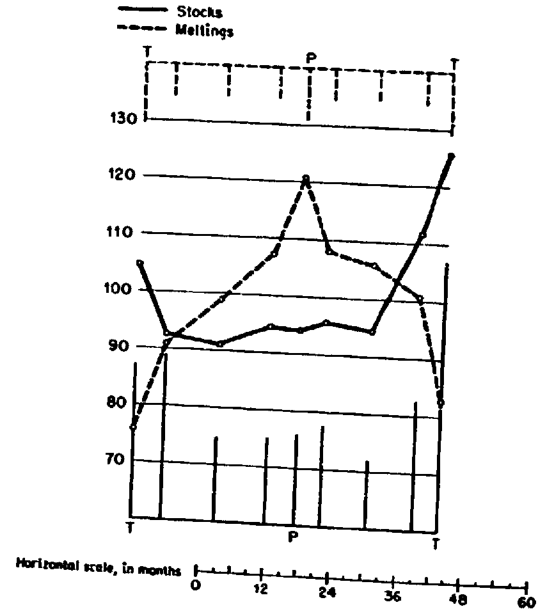
Raw sugar resembles the commodities already reviewed in that it is a farm product whose output is not readily adjusted to demand in the short-run. However, it need not be refined immediately. In consequence, though United States refineries absorb a major part of the sugar crops of this country, Cuba, Hawaii, Puerto Rico, and the Philippines, the size of the crops in these areas does not control the rate of sugar refining to the degree that the crop of cottonseed controls the production of cottonseed oil.

[19] The conformity measures for cottonseed stocks at mills run −20, −33, −60, but this apparent indication of inverse correlation can reflect only the accidental course of cotton crops during 1918-38, the period to which the figures apply.

In these circumstances, the behavior of stocks of raw sugar at United States refineries bears a certain similarity to that of total, not mill, stocks of cotton and silk and to that of crude rubber stocks. The relative weakness of demand factors is apparent in the slight conformity of raw sugar stocks to general business activity: conformity indexes for 13 cycles 1890-1938 run +23, 0, −8. Sugar stocks, in contrast, are positively correlated with the movements of total United States supply, i.e., both domestic production and imports. The coefficient of correlation based on annual directions of change in these two series between 1890 and 1939 is +.38, allowing for a 6-month lag of stocks behind supply.[20]

At the same time, there are faint indications that stocks tend to be drawn down when sugar refining increases and to pile up when refining declines. The conformity measures for raw sugar stocks during 10 cycles of sugar meltings 1891-1940 run −20, −9, −20. The average cycle patterns are shown in Chart 31.

Chart 31
Raw Sugar Stocks and Meltings
Average Patterns during 10 Meltings Cycles, 1893-1940



[20] The index would be somewhat higher if we omitted the years of World War I and its aftermath when stocks were virtually exhausted, then rebuilt.

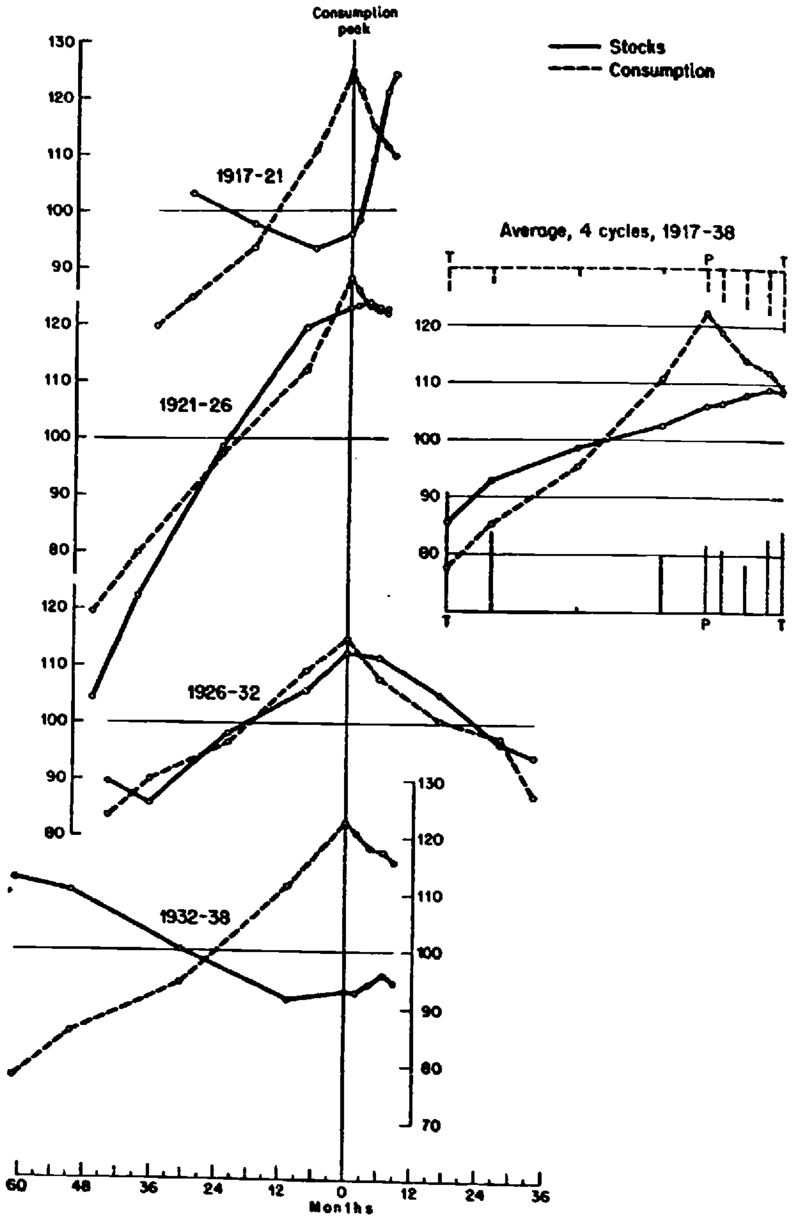
7 *Crude Petroleum*

From commodities that are products of agriculture we turn to materials that have their source in mining or manufacturing operations. The supply of the first of these, crude oil, has in the past been marked by circumstances of the same inflexible and fortuitous character as makes the adjustment of agricultural output to demand so difficult and sluggish. The direct cost of producing crude oil, once a successful well has been sunk, is very low and under certain conditions may be negative, for the pools of oil underlying the wells of different firms are connected. Hence unless an entire field curtails production, individual firms who do curtail are, in effect, despoiled of their assets. Deliberate downward adjustments of supply to demand are, therefore, dependent upon cooperative action, which did not assume effective form until the 'thirties. Fluctuations in supply, in addition, have been seriously influenced by the more or less accidental discoveries of new oil fields and their exploitation. As we shall see, a good part of the movements of stocks can be traced to the sudden increases in output when new areas are opened.

Other salient characteristics of the industry are that stocks held on petroleum producing properties are very small and that the oil commonly passes into the ownership of the refining companies when it leaves the producing property. A considerable portion of the oil wells, of course, are owned by the refining companies. Stocks held on producing properties east of California, for example, have typically accounted for about 3 percent of the total stock in that area. It seems valid, therefore, to treat the total stock of petroleum as a stock owned by the refineries.

The relation between stocks and petroleum consumption in refineries reflects the accidental timing of oil field discoveries and the sluggish, even perverse, response of the rate of exploitation to changes in demand. Chart 32 shows the cycle patterns of crude petroleum consumption between 1917 and 1938 and the patterns of petroleum stocks during consumption cycles. The absence of a close relation between stocks and consumption, confirmed by conformity indexes of 0, 0, and +14 during 4 consumption cycles 1917-38, can be explained by developments during the various consumption cycles.

Chart 32
Petroleum Stocks at Refineries and Crude Petroleum Consumption Patterns during Consumption Cycles



The first cycle, from December 1917 to August 1921, is the only one of the four for which we have records that was free not only from the effects of the discovery and exploitation of large new fields but also from the influence of industry or governmental attempts to regulate competition in the production of crude oil. The pattern of stocks is clearly inverse to that of consumption.

The second cycle, August 1921 to February 1926, was dominated by the output of new fields. Of the 260 million barrel increase in the output of crude oil in the United States between 1921 and 1923, almost all came from new areas. Discoveries in the Los Angeles Basin raised the output in that region 170 million barrels, from 35 million in 1921 to 205 million in 1923; 30 million barrels more came from the new Smackover area of Arkansas. After reaching a high point in 1923, production in the Los Angeles area declined and in 1925, the peak of the consumption cycle, was some 50 million barrels lower. Total production was maintained, however, by further exploitation of the Smackover area, which produced 42 million barrels more in 1925 than in 1923, and by the opening of the West Texas field, which produced nothing in 1923 but yielded 10 million barrels in 1925. Thus the rise of stocks during the expansion of consumption from 1921 to 1925 may be laid to new fields. In the short contraction that followed, July 1925 to February 1926, consumption declined little. It is to this fact, together with the absence of striking new discoveries, that we may attribute the leveling off of stocks in this period.

The growth of stocks during the following expansion in consumption, February 1926 to October 1929, again reflects the influence of discoveries. Both the West Texas field and the newly discovered Seminole Field in Oklahoma began to produce large quantities in 1927. The Los Angeles Basin, which had been producing approximately 150 million barrels per year from 1924 through 1928, suddenly jumped to 208 million barrels in 1929. The production of these three fields together was some 278 million barrels higher in 1929 than in 1925; total United States production increased only 208 million barrels.

It is difficult to say to what extent the decrease in stocks during the contraction in consumption from 1929 to 1932 reflects a normal contraction of supply in response to a decline in demand.

In part, the smaller output is due to a natural decline after the flush production in the new fields which ended in 1929. Exploration and investment in new areas also were probably curtailed. In part, the control of production enforced by martial law in Oklahoma and Texas, and applied as well in Kansas, was effective.

In the subsequent expansion of consumption stocks declined. Again it is not clear whether output could not be increased as fast as consumption or whether the control of output, effective since 1934 under the federal conservation program, was a more inportant influence. That the control did not operate swiftly enough to prevent stocks from rising during the 1937-38 contraction is probably significant.

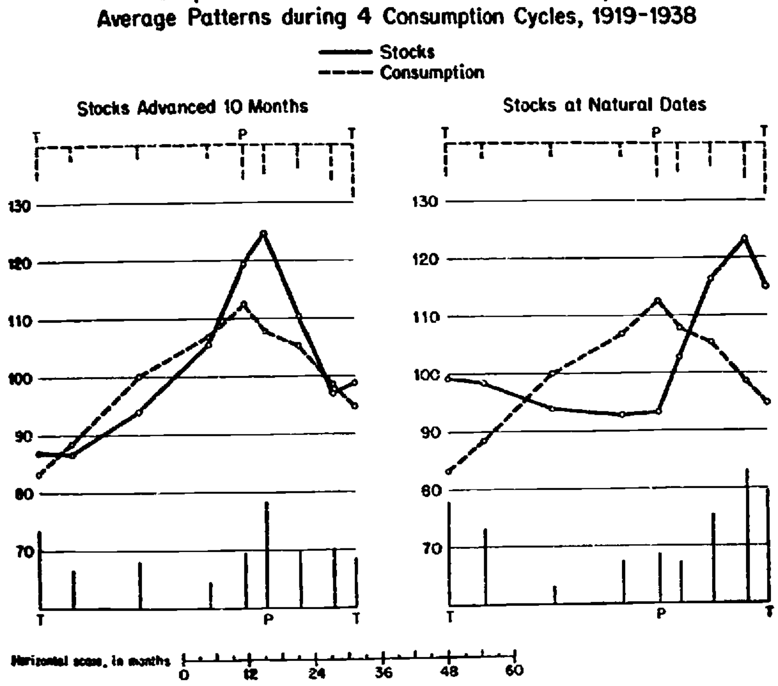
To extract lessons of general significance from the record of crude petroleum stocks is obviously difficult. Accidental changes in the supply situation and voluntary and governmental control of production influenced the course of events too markedly in the period under review to permit much insight into the forces that would rule the industry in the absence of these factors, or into those that may rule if cooperative or governmental regulation of output becomes more effective.

8 *Newsprint at Publishers*

Newsprint held by publishers is our only clear case of a raw material supplied from relatively nearby sources and produced by manufacturers who can expand or contract their rate of output readily. Since manufacturers also keep stocks of paper which they draw down or allow to accumulate to meet changes in demand, and since the price of newsprint is exceptionally stable, stocks held by consumers of newsprint would seem to be susceptible of management in accord with publishers' views of the requirements of manufacturing convenience. We would expect to find stocks rising and falling in close company with newsprint consumption.

Such, however, is not the case. Publishers' stocks of newsprint do move up and down with newsprint consumption, but only with an extraordinarily long lag. Stocks lagged behind consumption at each of four peaks and four troughs of consumption; the average lag at peaks was 10.5 months, and the average lag at troughs, 9.5 months. If a 10-month lag at both peaks and troughs is allowed for, the conformity of stocks to cycles of consumption is indicated by indexes that run +50, +100, +100. Chart 33 shows the average pattern of stocks during consumption cycles with stocks advanced 10 months. Parallel with it is the average pattern of stocks during consumption cycles without allowance for lag. Apparently the lag of stocks is so long as to produce almost completely inverted behavior. That the true relation of stocks to consumption, however, is that of a laggard reaction in the same direction rather than an inverse relation is suggested by the lower conformity yielded by synchronous analysis: 0, —50, —43, and this belief is strengthened when we consider the marketing arrangements in the industry.

Chart 33
Newsprint: Stocks at Publishers and Consumption
Average Patterns during 4 Consumption Cycles, 1919-1938



The long lag of stocks behind consumption has a simple explanation. Newsprint is purchased on long-term contract. Cranston Williams, General Manager of the Newspaper Publishers Association writes, May 24, 1942:

"... The general practise is that newsprint contracts are made for a certain annual amount of tonnage, the shipments to be made in equal monthly installments to the publisher.

As a rule, newsprint contracts are made in the fall of the year and run on a calendar-year basis.

Any deviations from the general practises . . . are a matter between purchaser and seller."[21]

The contracts are not an absolute bar to changes in the rate of newsprint shipments within a given year. Presumably, mills will accept orders for additional supplies, within their capacity, thus affording some flexibility to supply in an upward direction. And there is probably some margin of expected current demand not covered by annual contract which may afford some flexibility in either direction. But since annual contracts are the rule and since they generally begin, and therefore end, at the same time, the rapidity with which publishers' receipts of newsprint can respond to changes in consumption must be seriously reduced. The result is the long lag of stocks.

9 *Iron Ore Stocks at Blast Furnaces and at Lower Lake Ports*

Iron ore stocks are, in some ways, the most interesting of the commodities in our sample. They have the singular and paradoxical virtue of illustrating the effect on raw material stocks of a supply that can be readily adjusted to changes in demand and of one that can hardly be adjusted at all. The explanation lies in the fact that ore is transported principally over the Great Lakes. Additional quantities can, therefore, be brought to the furnaces in the quantities desired during the months when the Lakes are open to navigation. During the winter months, however, the Lakes are blocked with ice, and supply to the furnaces is almost completely inflexible. This fact is the key to an inventory behavior otherwise peculiar and puzzling.

Iron ore is mined mainly in the Lake Superior region and, as said above, brought by freighter through the Great Lakes and thence by railroad to furnaces in Ohio, Pennsylvania, and Illinois.[22] Ore mined in this area is stocked chiefly at three points—at

[21] The Federal Trade Commission, Report on the Newsprint Paper Industry, 1930, found that the contracts of the larger newsprint manufacturers ran even longer. About half were for five years or longer, but it is not clear—and it seems improbable—that the longer contracts call for deliveries at constant monthly rates during their entire life.

[22] The states comprising this iron-mining region—Minnesota, Michigan, and Wisconsin—produce about 85 percent of all the iron ore mined in the United

the mine, on the Lake Erie and Lake Michigan receiving docks, and at the blast furnaces (Table 45).

TABLE 45

Consumption and Stocks of Lake Superior Iron Ore (thousands of long tons)

	1920	*1921*	*1929*	*1932*	*1937*
Consumption, mo. av.[a]	4531	2029	5304	857	
Stocks					
At furnaces, mo. av.[a]	21211	24512	24577	27744	
On Lake Erie docks, mo. av.[a]	8542	8818	3033	5425	
At mines, Dec. 31[b]	10367	12574	6108	16408	5261

[a] From Lake Superior Iron Ore Association as reported in *Survey of Current Business*, annual supplements.
[b] From Bureau of Mines as reported in *Mineral Resources* and *Minerals Yearbook*.

Stocks are evidently large in comparison with consumption. At the furnaces they constituted about 5 months' supply on the average in the two good years, 1920 and 1929. In the poor year, 1921, the furnaces held a supply equal to twelve times their monthly consumption, and in the worst year, 1932, stocks covered monthly consumption 30 times. On the docks, stocks are lower, varying between 1 and 2 months' supply in good years to 5 months' supply in bad years. Stocks at the mines cannot be compared as easily with consumption since we have figures only for December 31, but apparently they are in an intermediate position between holdings at furnaces and at docks.

The total holdings of Lake Superior ore relative to its rate of consumption are probably understated somewhat. Some ore is landed at Lake Michigan ports and a supply of ore is kept at these points. If the average size of this supply is in the same proportion to receipts of ore at Lake Michigan ports as the holdings on Lake Erie docks are to receipts at Erie ports, the holdings at docks should be raised about 25 percent. And some ore, finally, is in transit by land and, in summer, by water from the mines to the furnaces.

These figures do not cover all the iron ore held in the United

States, and almost 95 percent of the ore mined outside Alabama. Since most of the Alabama ore is used in the South, the Lake Superior region is the only supplying region of importance for the major pig-iron producing region—Pennsylvania, Ohio, and Illinois. Imports from abroad have been negligible.

States. About 15 percent is produced outside the Lake Superior region. In 1937 other mines held 265 thousand tons; Lake Superior mines 5.5 million tons; pig iron produced in the South, made largely from iron ore mined in Alabama, was some 15 percent of the national total. Ore held at the southern furnaces may, therefore, be substantial. Unfortunately, data on these holdings are not available. But the figures at hand cover most American iron ore holdings. Our discussion is confined to stocks at lower lake ports and at furnaces, categories of ore that presumably have passed into the ownership of pig iron manufacturers.

IRON ORE CONSUMPTION AND STOCKS

Iron ore is moved from the mines by railroad to Lake Superior ports, thence by freighter to ports on the southern shores of Lake Erie, and, in smaller quantity, to those of Lake Michigan. From these docks, where relatively small but still substantial stocks are kept, the ore goes to the furnaces where the accumulation is largest. These piles at furnaces and on the docks are the stocks from which the furnaces directly draw their supplies.

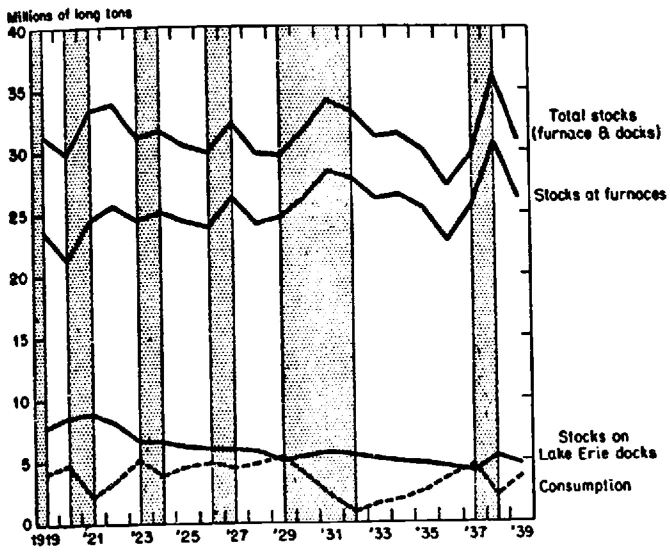
Chart 34 shows the standing of these stocks in the form of monthly averages for calendar years,[23] and the average monthly consumption of iron ore. The inverse relation between stocks and consumption is marked. Total stocks and stocks at furnaces, which dominate the total, were lower at the end than at the beginning of every expansion in consumption (white areas); they were higher at the end than at the beginning of every contraction (shaded areas). In only 4 of the 20 years did consumption and stocks at furnaces change in the same direction. For total stocks there were only three similar movements.

The tendency to inverse conformity is hardly less strong in the movements of stocks on Lake Erie docks. In only 3 of the 20 years did consumption and stocks move in the same direction. But since stocks were higher at the end of one expansion, 1919-20, and lower at the end of one contraction, 1923-24, than they were at the beginning, the National Bureau standard conformity measure could not indicate perfect inverse conformity.

While the tendency to inverse conformity is clear in the an-

[23] Figures for stocks on Lake Michigan docks are not available.

Chart 34
Iron Ore: Stocks at Furnaces and on Lake Erie Docks and Consumption, Monthly Averages



Shaded areas indicate periods of contraction in consumption; white areas, expansion.

nual data, the reasons are more complex than usual, and to understand them we must study the monthly figures.

A peculiar method of studying monthly iron ore stocks is dictated by the character of the seasonal fluctuations in furnace and dock stocks. At blast furnaces stocks regularly reach a seasonal peak in October or November just before navigation on the Great Lakes closes for the winter and further shipments from Minnesota and Michigan are blocked. During the winter the stock pile is reduced by consumption and reaches a seasonal low in April or May depending upon the date when Lake shipments again become feasible. Stocks on Lake Erie docks follow a closely similar pattern. Only in 1932 was this pattern not followed with fidelity in either series. The movements from April to October are large both absolutely and as a proportion of the average stocks carried, and the movements of stocks at furnaces are substantially larger than those on docks by either method of measurement (Table 46).

The crucial peculiarity of these intra-annual fluctuations is that they are subject to changes in the amplitude of their swings and that these changes are themselves closely correlated with business

TABLE 46

Iron Ore Stocks, Average Seasonal Fluctuations, 1918-1939

AVERAGE CHANGE	AT FURNACES	ON DOCKS
1) April-October, millions of tons	+14.9	+2.1
2) April-October, as % of av. monthly stocks	+58.9	+34.5

cycles. The year to year change in the amplitude of the seasonal swings is evident in Table 47.

Whether we measure in percentages or in physical units, the average change between seasonal troughs, April to April, is larger than that between seasonal peaks, October to October, implying that the seasonal swings vary in size from year to year. Now if these changes in the seasonal fluctuation were not affected by cyclical influences but were a manifestation only of the effect of some noncyclical force acting on the intra-annual swing, we might reasonably attempt to free our data from the effects of both the ordinary seasonal influences and those which act to modify the seasonal amplitude. Kuznets' 'amplitude correction' factor—a measure of the degree to which the amplitude of the seasonal swing in a given year differs from the normal amplitude—is a well known device for accomplishing this and was used in an early analysis of the series.[24]

TABLE 47

Iron Ore Stocks, Average Annual Changes, 1918-1939

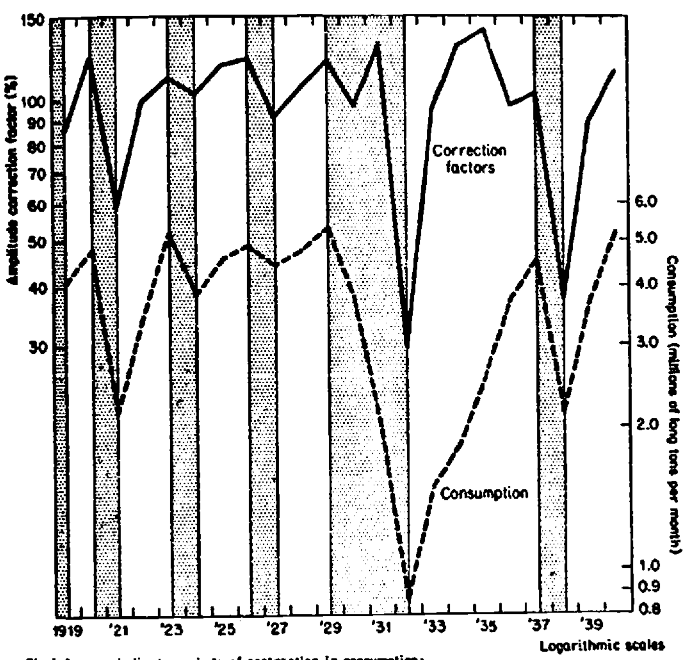
	AT FURNACES	AT FURNACES & ON DOCKS
April-April		
Millions of tons	3.9	4.6
As % of preceding year	22.3	22.6
October-October		
Millions of tons	2.0	2.1
As % of preceding year	6.2	3.4

In this instance, however, the amplitudes of the intra-annual movements are not uncorrelated with cyclical influences. Chart

[24] To calculate the factor for a given year, one computes the regression coefficient of the relative deviations of the original data from their annual average on the deviations of the ordinary seasonal index from 100. The deviations of the seasonal indexes from 100 are then multiplied by the coefficient to provide corrected indexes that take account of the abnormal character of the seasonal swing.

35 shows the amplitude correction factors for stocks at furnaces plotted against the consumption of iron ore, 1919-34. The two series agree almost perfectly in direction of movement, and there is even considerable similarity in the relative size of the fluctuations.

Chart 35
Iron Ore: Consumption and Amplitude Correction Factor for Seasonal Indexes of Stocks at Furnaces



Shaded areas indicate periods of contraction in consumption; white areas, expansion.

If the seasonal amplitude changes cyclically, as Chart 35 indicates, the effect of cyclical influences upon the standing of stocks must be different at different seasons (or in different months). This must be true with respect to either the amplitude or the direction of the seasonal movement; for clearly a wider intra-annual swing in years of good than of bad business must mean one of two things: (a) the standings of stocks at the seasonal troughs and those at seasonal peaks have moved in different directions from prosperity to depression or (b) they have moved in the same direction but by different amounts.

The elimination of seasonal influences, when changes in seasonal amplitude are allowed for, must, in such a case, hide certain essential features of the cyclical fluctuations, for it would remove or distort the effect of cyclical influences on seasonal changes. The application of a constant seasonal index, on the other hand, leaves the relation between the standings of our series in the same months in different years unchanged.[25] It therefore hides nothing we wish to study; but it does not do any good. If, as we now know, the effect of cyclical influences is different in different seasons or months, our sole alternative is to study cyclical fluctuations in the standings of stocks in each month separately. We can do this as effectively from the original data as from seasonally corrected data, and more directly.

Chart 36 shows the standings of stocks at furnaces for the same months in different years. The standings in each month, that is, are plotted as an annual series. Consumption in corresponding months is plotted with each of the above series for comparison. While the various consumption series resemble one another, the stock series differ markedly among themselves and in their relation to their companion consumption series. Clearly the relation

TABLE 48

Iron Ore Consumption and Stocks at Furnaces, 1918-1940

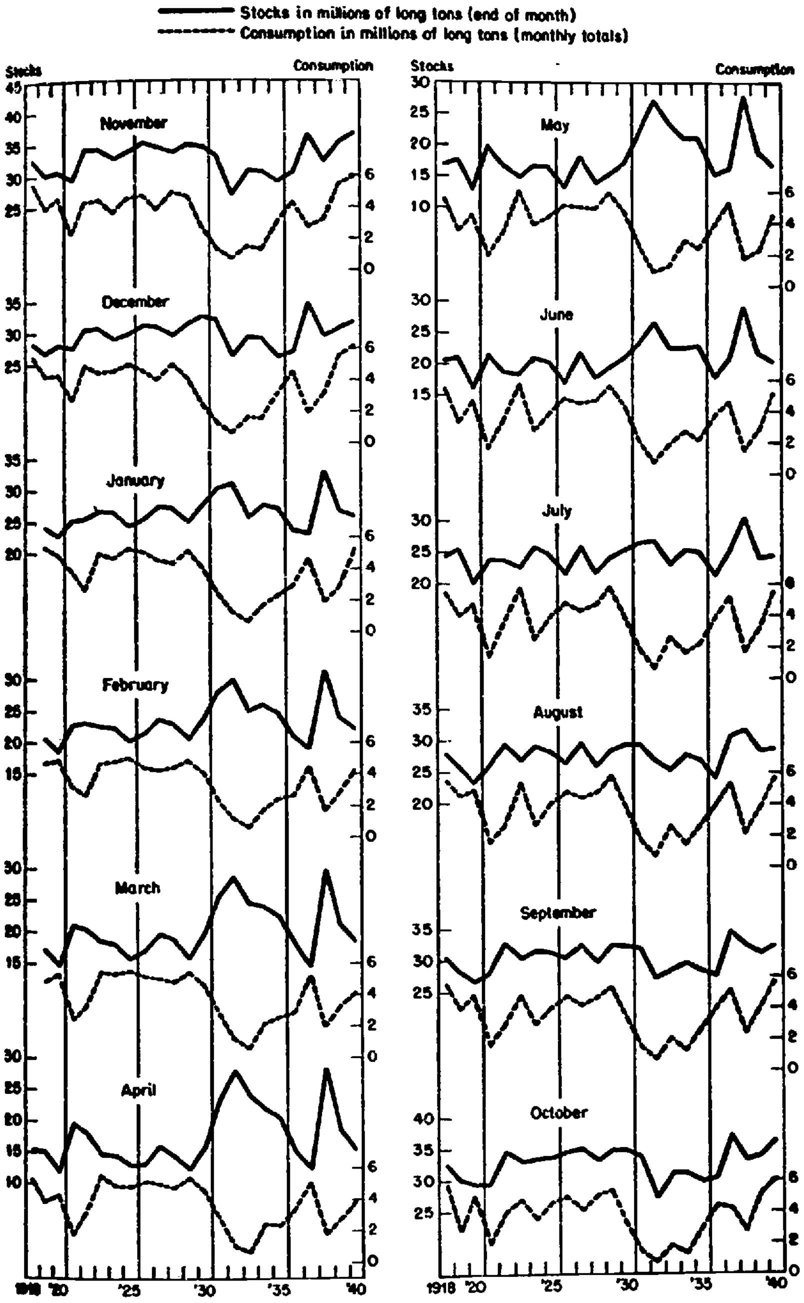
MONTH	NO. OF YEARS WHEN DIRECTION OF CHANGE WAS The same	Different	NO. OF YEARS WITH NO CHANGE IN STOCKS[a]	AV. DEVIATIONS OF Stocks	Consumption (millions of tons)
(1)	(2)	(3)	(4)	(5)	(6)
November	16	5	1	2.1	1.2
December	13	9		1.7	1.3
January	6	15		1.9	1.3
February	2	19		2.4	1.2
March	3	18		3.3	1.4
April	7	15		3.9	1.3
May	3	18	1	3.1	1.3
June	2	19	1	2.1	1.2
July	4	18		1.6	1.3
August	6	16		1.7	1.3
September	10	12		1.8	1.3
October	12	7	3	2.0	1.3

[a] Consumption changed in every year.

[25] That is, the relative differences are unchanged if the seasonal correction is accomplished by multiplying or dividing the original data for the same months in different years by the same factor. The absolute differences are unchanged if the correction involves the addition or subtraction of a constant number.

Chart 36

Iron Ore: Stocks at Furnaces and Consumption, Annual Data by Months



between stocks of iron ore at furnaces and the cyclical fluctuations in consumption depends upon the season of the year, as is brought out more fully in Table 48.

A fairly definite progression in the relation between stocks and consumption can be seen. In November, when stocks are at their seasonal peak, stocks and consumption move in the same direction in a rather large majority of years. In December there is only a slim majority of conforming movements, in January the majority of the movements are in opposite direction, and from January through August stocks and consumption tend strongly to vary inversely. In September the forces are again fairly equally balanced and by October the scale has tipped once more toward positive conformity.

FACTORS INFLUENCING CYCLES IN STOCKS

This rather strange behavior is not difficult to understand once its connection with the Great Lakes supply route for iron ore is appreciated. During the months when the Great Lakes are closed to shipping, stocks at blast furnaces can be replenished only by drawing down the much smaller piles of ore on the receiving docks. It is hardly surprising then that at the end of winters of good business, stocks should be especially low. In winters of poor business, on the other hand, stocks are drawn down slowly and at the end of the winter stand at abnormally high levels for the season. The upshot is that from January through May, months when the Lakes are closed or hardly reopened, the year to year movements of stocks are regularly inverse to those of the rate of consumption. To prevent this would indeed require rather accurate forecasting months in advance, together with a determination to provide fully for an expected increase in business.

During the open months, from April or May through November, stocks at the furnaces are rebuilt in preparation for the winter. Moreover, when business improves, iron manufacturers increase the amount of ore they hold in preparation for winter production. Stocks held at the end of November tend to move from year to year in the same direction as consumption. This is consistent with what we expect when manufacturers are in a position to control their rate of materials supply.

While these inventory preparations during the open season help manufacturers to carry on their business from the close of navigation until the ice goes out, the extent of the preparation is not sufficient to prevent the annual changes of stocks between one closed season and the next from being inversely related to consumption changes. Indeed, the annual change in stocks between the same spring months of different years—after navigation has been closed for some months—is typically larger than that from November to November (Table 48). The average deviation of stocks in November from the mean level for that month is 2.1 million tons. It is somewhat lower, though not very different, from December through February. In March, however, the average deviation is 3.3 million tons, in April, 3.9, and in May, 3.1. It is these relatively large fluctuations of stocks in months when the relation between stocks and consumption is normally inverse that dominates the annual stocks figures and causes them also to move inversely (Chart 34).

This suggests that to meet the difficulty caused by ice on the Lakes, the manufacturers depend only partly on their ability to anticipate business changes during the winter by varying the level of stocks accumulated by the close of navigation. Their main reliance is on the large reserve they accumulate by November every year. We have already seen what large stocks are normally kept at the furnaces (Chart 36). The adequacy of these stocks may be judged from the fact that in April 1920 when, after a winter of high consumption, stocks were lower than in any month covered by our data, furnaces still held a supply equal to 2.5 months' consumption at the rate then current. In addition, there remained as a last resort the stocks on Lake Erie and Lake Michigan docks, a substantial supply in itself. Since iron ore users can keep such large stocks, it is little wonder that they are content to allow them to be drawn down in winters of good business.

At first sight it is somewhat surprising that even in June, after the Lakes have been opened for some weeks, the relation between stocks and consumption is still inverse. And still more surprising that this should remain true through August. Not until September does this inverse relation disappear, and in October the evidence for positive conformity is still very weak.

Again the reason seems clear. Immediately following a winter of good business stocks are abnormally low. During the ensuing months they are gradually rebuilt. If stocks are low in May when the Lakes open, they will not be rebuilt in the next four weeks to normal June levels, though some progress will be made. If stocks are still low in June they will not be rebuilt in the next four weeks to normal July levels, and so on. It is, therefore, quite consistent with the relatively large fluctuations in stocks during the winter and early spring months that the effects of these large variations are not overcome until early autumn.

If this explanation is correct, one would expect to find that the variation in stocks between the same months in different years becomes smaller as the year proceeds through spring and summer, and larger again in the autumn as the influence of the current and expected rate of consumption makes itself felt. This is, in fact, what we find. The average deviation of stocks is highest in April, 3.9 million tons; by May it has fallen to 3.1 million tons; in June it is 2.1, in July 1.6, in August 1.7. From this point, it rises to a second peak, 2.1 million tons, in November.

For similar reasons it is not surprising that, at the end of December after the Lakes have been closed for four weeks, stocks at furnaces still move in the same direction as consumption in a majority of years. But their amplitude in this month (the average deviation is 1.7 million tons), is lower than at the seasonal peak in November (2.1 million tons). This argument is completed in a formal sense by noting that in column 6 of Table 48 there are no comparable changes in the amplitude of consumption cycles, each month taken separately.

For a longer period, since 1887, figures for stocks held on Lake Erie docks at the opening and closing of navigation (that is, approximately on April 30 and November 30) confirm the findings for furnace stocks. Stocks held at the opening of navigation, about April 30, moved in the same direction as consumption in only 15 of 57 years. This represents a somewhat stronger tendency to inverse conformity than may be apparent at first sight since both stocks and consumption were subject to a strong upward trend from the beginning of the period until about 1918. On the other hand, the tendency for stocks held at the close of navigation to vary in the same direction as consumption is undoubtedly weaker in the case of stocks held on docks than in the case of furnace stocks. Despite the similarity of trend, stocks and consumption moved in the same direction in only 32 years. There can be little doubt, however, about the significance of the difference in behavior between stocks held at the opening and closing of navigation.

As in the case of furnace stocks, the difference in the amplitude of fluctuations in stocks held on docks at the opening and closing of navigation is striking. The average deviation was .46 million tons at the close of navigation and .74 million tons at the opening.[26]

Since 1918 similar figures were computed for the sum of stocks at furnaces and on Lake Erie docks for four months: April and May to represent the position at the opening of navigation, and October and November to represent the position at the close of navigation. The results are similar to those for furnace stocks alone. In 13 of the 22 years stocks in October moved in the same direction as consumption while in 2 additional years stocks did not change though consumption did. Between Novembers, stocks moved in the same direction as consumption in 17 of the 22 years. For April and May our findings were quite different. Between Aprils, stocks moved in the same direction as consumption in only 7 years; between Mays, in only 3 years.

The behavior of iron ore stocks is a striking illustration of how manufacturers' capacity to adjust the rate at which they receive raw materials affects the relation between cycles in inventories and in business. Cycles in the level of ore stocks held in months when the Lakes are closed to navigation, and for some months thereafter, move inversely to ore consumption. Stock cycles for months at the end of the open season, however, tend to vary directly with consumption. Thus iron ore stocks show the effects of both kinds of supply conditions which otherwise separately influence the behavior of individual commodities. Commodities whose rate of receipt cannot be adjusted readily to changes in requirements tend to vary inversely to consumption. Most commodities, however, appear to be supplied under conditions that do permit rapid change

[26] Because stocks on docks were influenced by a substantial trend factor, the average deviations were computed from the standings of a 9-point moving average, smoothed by a free hand curve.

in the rate of delivery to manufacturers. These, I think, will tend to vary directly with consumption.

10 *Lead Stocks at Bonded Warehouses*

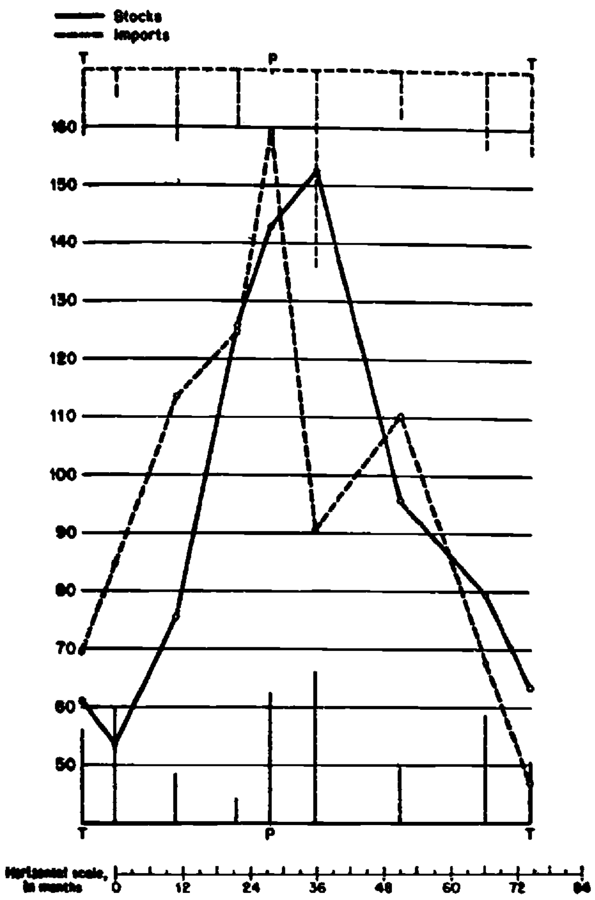
During 1895-1918 the lead held at warehouses was imported largely from Mexico. Only a minor quantity was destined for consumption in this country; most of it came for processing in bond and re-export. Consequently, the series has a mixed character showing some of the attributes of a raw material, as we use the term, and some of the attributes of goods in process.

Although no direct evidence on the rate of consumption of these materials is available, withdrawals from bond have been estimated on the basis of imports and changes in stocks. Imports and withdrawals move in close conformity and with no significant difference in timing. I have, therefore, used directly recorded imports rather than withdrawals to measure activity. The latter are not only based on estimates, but measure a stage later than the processing of raw materials, just as imports record an earlier stage. The fact that imports and withdrawals from bond reach cyclical peaks and troughs at about the same time is presumptive evidence that the same is true of the rate of refining in bond, which would be a better measure of consumption.

The conformity of stocks to cycles of imports was high. Conformity indexes for 3 cycles 1896-1916 run +100, +100, +100. Stocks, moreover, give evidence of a tendency to lag behind turns in manufacturing activity, as far as the latter can be judged from imports. (This is, of course, consistent with our expectation about the behavior of the stock of an imported material produced by mining or manufacturing.) Including incomplete cycles at the beginning and end of the series, turns of stocks can be observed at nine turns in imports. According to the cycle patterns, stocks reached a trough or peak later than imports on five occasions and turned in the same stage four times. Stocks never led. This tendency to lag is confirmed by the average patterns in Chart 37 which shows stocks reaching a trough in stage II of imports cycles and a peak in stage VI.

Timing comparisons made in the National Bureau's usual fashion, that is, by comparing the months when stocks and imports

Chart 37
Lead: Stocks at Warehouses and Imports
Average Patterns during 3 Import Cycles, 1896-1916



reach peaks or troughs, also suggest a tendency for stocks to lag. Of 5 comparisons at peaks, stocks lagged twice, led twice, and turned synchronously once. At troughs, they lagged in 3 of 4 comparisons and led once. The average lag at both peaks and troughs was 3 months.

11 Recapitulation

The analysis of these cases is a far less adequate basis for generalization than one could wish. But a more adequate basis does not exist today. The description and explanation of the cyclical behavior of stocks of raw materials that seems to me most consistent materials, stocks are unlikely to rise and fall synchronously with production. A firm will not immediately alter its level of purchases with each dip in requirements, and time is required for a reduction in purchases to be reflected in smaller arrivals of merchandise. Stocks of raw materials are, therefore, likely to lag behind production in the firms holding the stocks. I have estimated the length of such lags to be two or three months.

4) When commodities are imported or procured under long-term contract, the lag of stocks will be much longer. This tends to lengthen the lag of total stocks of materials.

5) When commodities are of agricultural origin and no buffer stock held by dealers is available, manufacturers' stocks must absorb the haphazard fluctuations in supply caused by weather and pests. Such stocks will fluctuate irregularly during business cycles and introduce a minor random element into the movements of manufacturers' total stocks of raw materials.