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ECONOMIC EXPECTATIONS AND PLANS OF FIRMS IN RELATION TO SHORT-TERM FORECASTING

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A. *Summary*

OVER THE LAST TWO DECADES a number of agencies, for various reasons, have been surveying the sales expectations of large samples of firms. The purpose of this paper is to analyze the usefulness of such surveys for short-term economic forecasting. By "short term" we mean a period of three to six months.

Our analysis utilizes survey data from three primary sources:

1. The forecasts of the Regional Shippers' Advisory Boards of the Association of American Railroads. We shall hereafter refer to these forecasts as the "shippers' forecasts." They have been prepared on a quarterly basis and were first published in 1927. They report

This paper is a progress report on certain phases of a research project, "Expectations and Business Fluctuations," conducted at the University of Illinois under the auspices of the Merrill Foundation for the Advancement of Financial Knowledge. Our discussion is limited to only some of the results we have obtained and many of these must be considered tentative because the project is not yet complete. For a more complete coverage we must refer the reader to a number of monographs as well as to a summary volume which we expect to publish in the near future.

It would be impossible to give full credit to every member of the group who has contributed to the content of this paper. However, we are especially indebted to Bernard J. Marks for competent direction of much of the research as well as for many ideas incorporated in this paper. Among others who have assisted us liberally are Jack Feldman of the National Opinion Research Center in Chicago, Jean Bronfenbrenner, Robert Ferber, Irwin Katzman, and Avram Kisselgoff. We also have benefited greatly from consultations with many of our colleagues, especially Howard Bowen, Leonid Hurwicz, and Albert Hart.

In addition we would like to acknowledge the generous cooperation of *Fortune* magazine and of Dun & Bradstreet. The pioneering work of these firms in surveying businessmen's expectations has contributed substantially to the supply of data in an area in which there has been little material available.

the carload shipments expected for the next quarter by a large sample of firms in the manufacturing, mining, and agricultural industries.

2. *Fortune* magazine, Executive Forecasts. These forecasts were obtained by means of a survey that secured information from several thousand top executives of firms in manufacturing, mining, public utilities, communication, and financial institutions. The survey was conducted on a semiannual basis from November 1946 to May 1950.

3. Dun & Bradstreet, Survey of Business Trends and Business Expectations. This survey covers, primarily, small and medium-sized firms in the fields of manufacturing and retail and wholesale trade. It was initiated in the spring of 1947 and sixteen surveys had been conducted at the time this paper was prepared.

In section B we discuss the nature of these surveys, the methods by which they have been conducted (as far as is known to us), and their limitations for the purpose of our analysis.

In parts of our analysis we have also utilized some of the data on sales expectations gathered by the Office of Business Economics, Department of Commerce, and the Securities and Exchange Commission in the course of their survey of capital expenditures anticipated by business firms.

The use of surveys of anticipations for short-term forecasting is analyzed from two different points of view. In section C we examine how accurately sales expectations have forecast the actual course of sales. In section D we endeavor to test whether data on sales expectations can be used for forecasting variables other than sales themselves, especially production and inventory movements.

To test the forecasting accuracy of the firms responding to the surveys we compute the percentage error committed by forecasters. We find that for all of the surveys analyzed the forecasts exhibit a substantial marginal error. For the prewar period, on the basis of the only available source (the shippers' forecasts) we find that this error, for all manufacturing industries combined, amounts to approximately 10 per cent. For the postwar period, where we have at our disposal several sources and several industries in addition to manufacturing, we find some variation, but in most cases the average error is between 5 and 7 per cent. These are rather large errors when one considers that the respondents were forecasting only three to six months ahead.

We also find that the errors committed by the respondents exhibit certain interesting regularities. In all of the surveys analyzed the respondents tended to overestimate sales for periods in which sales actually fell and to underestimate them for periods in which sales rose. For example, for 22 quarters between 1927 and 1941 when sales were falling, the shippers' forecasts were on the average 16 per cent *above* actual sales, and for 23 quarters in the same period when sales were rising, these forecasts were on the average 5 per cent *below* actual sales. This regularity results from the fact that the respondents frequently failed to anticipate the direction of change, and even when they correctly anticipated the direction they seldom were able to gauge the full extent of the change.

Knowledge that the error of forecasts has been around 10 per cent in the prewar period and between 5 and 7 per cent in the postwar period is of limited value unless we have some standard against which to measure the significance of this error. We proceed, therefore, to examine whether the forecasts made by the respondents are on the average any better than the forecasts that might have been made by simply extrapolating the latest level of activity. For this purpose we compute the average error that would have been committed by forecasting that sales in the next period would be equal to sales in the latest preceding period. We compare this error with the average error committed by the respondents. This analysis reveals some marked differences in the forecasting record of the four surveys analyzed.

In the case of the shippers' survey it is found that both in the prewar and in the postwar period the respondents' forecasts performed appreciably worse than a simple extrapolation of the recent past would have. In the prewar period, for instance, the average error committed by extrapolation would have been 8 per cent, whereas the average error of the shippers' forecasts was 10 per cent. Similar results are found in the case of the Dun & Bradstreet survey.

In the case of the *Fortune* survey the picture is surprisingly different. In four of the five types of economic activities analyzed by us the respondents' forecasts were better than a straight extrapolation, the difference in some cases being pronounced. For instance, in the case of durable goods the error of the respondents' forecasts turns out to be some 23 per cent smaller than the error of a straight extrapolation.

The forecasting record of the OBE-SEC survey also appears rather favorable in the light of this test. Our analysis in this instance is limited to data for only two years, 1948 and 1949. It appears, however, that in both cases the respondents correctly forecast the direction of change though they somewhat underestimated the magnitude of the change (see section C 4).

At the end of section C we advance some tentative explanations for the marked superiority, in terms of forecasting record, of the *Fortune* and OBE-SEC surveys over the shippers' and Dun & Bradstreet surveys.

In section D we develop certain mathematical models for the purpose of testing the significance of sales expectations in shaping the course of production and inventories. In these models we emphasize the role of inventories in permitting a firm to produce at a relatively even rate throughout the year even though its sales are subject to marked seasonal fluctuations (sections D 1-4). Statistical tests of these models are then carried out by fitting them to cross-sectional data of individual firms at a single point of time (section D 5) and to time-series of aggregates (sections D 6-7).

The tests described above are designed to throw light on three major questions: How well do our models describe the facts? Is there any evidence that economic expectations, as reported in sample surveys, have any influence on the course of short-term movements of production and inventories? Is information on expectations secured by sample surveys of any help in forecasting production and inventory movements?

The number of tests we have been able to carry out so far is rather limited. Nevertheless, the results with respect to each of the questions listed above are definitely encouraging. And although we are not yet justified in reaching any final conclusions, these results certainly suggest the desirability of continuing the type of analysis in which we have been engaged.

B. The Nature of Available Data on Expectations

Most of the analysis that follows is based on data from the three sources listed earlier. It will be convenient to give here a brief description of each of these.

1. Forecasts of Regional Shippers' Advisory Boards, Association of American Railroads

Since the middle of the 1920's the firms responsible for the bulk of our railway freight traffic have been members of the so-called Regional Shippers' Advisory Boards. The general function of these boards is to provide a medium through which the shippers can advise the Association of American Railroads of their shipping problems. Since around 1927 these boards have also been providing the railroads with a quarterly forecast of the number of cars required to move the shippers' products.

Shippers are divided into thirteen regional Advisory Boards and the members of each board are further divided into thirty-two major commodity groups, the definition of which has remained remarkably stable for the last twenty-five years. Each commodity group in each region is expected to provide a forecast of the number of cars required for the next calendar quarter, through a poll of its members conducted about six weeks before the beginning of the quarter. These regional forecasts are then collected by the Car Service Division of the AAR and published on the first day of each quarter in a release entitled "National Forecast of the Regional Shippers' Advisory Boards." (See also Thor Hultgren's discussion of these forecasts, in the paper immediately following this one.)

The specific methods of collecting and processing the individual shippers' forecasts have varied somewhat over time and from board to board. Generally, the secretary of the board mails out a questionnaire to each member asking for the number of cars the member expects to require in the coming calendar quarter and the actual number of cars shipped in the corresponding quarter of the year before. For each commodity anticipated requirements and actual shipments of the respondents are totaled, and the expected percentage is computed. The regional forecast is then calculated by applying this ratio to the total actual number of cars shipped from the particular region in the corresponding quarter of the year before. This forecast may be modified by the Commodity Chairman or at the quarterly meetings of the membership of the regional board, but such modifications seem to occur only exceptionally.

In certain boards, notably the Midwestern Board, which covers the Chicago area, this procedure is modified to the extent that information from the shippers is secured directly from the Commodity Chairman. In such cases, to avoid disclosure of information to a competitor (since the chairman of the board is a shipper), the shippers are asked only for the expected percentage change. With the help of this response the Commodity Chairman prepares the forecast. One would expect that forecasts secured by this procedure would tend to be less reliable than the ones secured through the more formal and systematic alternative procedure described earlier. However, a comparison of the forecasts with actual shipments in no way supports this hypothesis.

The coverage of the Shippers' Advisory Board survey varies from one commodity group to another, and from region to region. Available evidence indicates that firm representation varies from 25 to 80 per cent. In terms of actual shipments, however, coverage is generally higher because special efforts are made to secure estimates from the larger firms in a commodity group as well as from members of the commodity groups that are of greatest importance in that particular region. As a result the percentage of shipments represented is usually in the order of 50 per cent or more.[1]

In this paper we are concerned exclusively with forecasts relating to commodities that can be classified approximately as "manufactured commodities." In table 1 below we list the nineteen commodity groups included in the shippers' survey that can be so classified, and show, for the year 1948, the number of carloads of each commodity shipped, expressed as a percentage of shipments of all manufactured commodities.

TABLE 1

Manufactured Commodities Covered by Shippers' Survey and Their Relative Importance in 1948

	Carloads Shipped, as Per Cent of Total		*Carloads Shipped, as Per Cent of Total*
Flour, meal, and other mill products	8.4	Agricultural implements and vehicles other than automobiles	1.0
Salt	1.0	Automobiles and trucks	3.4
Lumber and forest products	19.1	Vehicle parts	3.2
Petroleum and petroleum products	14.9	Fertilizers, all kinds	5.5
Sugar, syrup, and molasses	1.9	Paper, paper board, and prepared roofing materials	7.8
Iron and steel	16.2	Chemicals and explosives	2.9
Other metals	1.2	Food products in cans and packages	2.8
Machinery and boilers	1.8	Frozen foods, fruits, and vegetables	0.1
Cement	5.0		
Brick and clay products	2.2		
Lime and plaster	1.4		

Source: Compiled from data of regional Shippers' Advisory Boards, Association of American Railroads.

[1] For at least two commodity groups the forecast is prepared by a single agency representing the shippers and is not the aggregate of individual firms' forecasts. The first of these two cases is the commodity group, automobiles and trucks; for this group the estimates for every region are prepared by a single

For further discussion of the design of the survey, the quality of the sample, and the reliability of the replies, the reader is referred to "The Railroad Shippers' Forecasts," prepared by Robert Ferber as part of the Merrill Project and published as *University of Illinois Bulletin* 74, June 1953.

2. FORTUNE MAGAZINE, EXECUTIVE FORECASTS

For several years *Fortune* magazine has been conducting a survey of a large sample of top executives. These surveys are known as the "Forum of Executive Opinion." Eight of them, those started in November 1946 and conducted in May and November of each year through May 1950, provide answers to questions about economic expectations.

The *Fortune* questionnaire typically consists of three sets of questions:

1. A battery of questions relating to expectations about the future state of business in general and about the future level of such indexes as the gross national product, Federal Reserve Board index of production, and Bureau of Labor Statistics cost of living index.
2. A battery of questions relating to expectations and plans of the respondent's firm. This section includes questions on sales, profits, selling price and purchase price expectations, expected change in investment and inventories, etc. At our suggestion questions relating to recent business experience were added in later surveys.
3. A number of questions under the heading "Current Opinions." These questions relate to attitudes toward certain current issues of a political-economic character.

The *Fortune* questionnaire is generally addressed to a list of many thousands of respondents. Though a detailed discussion of the mailing list is beyond the scope of this paper, it can be said that the sample is not scientifically designed. Broadly speaking, it is a large sample of top executives of medium-sized and large firms across the country. The number who actually reply to the questionnaire has been usually about 4,000 to 5,000, but this does not represent a high rate of response.

To interpret the rate of response correctly, however, it should be

agency in Detroit. The other case is coal, where, in at least one region, the forecast is prepared by the local coal operators' association. In the case of automobiles and trucks, tests carried out suggest strongly that the forecasts are distinctly poorer than average.

noted that *Fortune* has classed the respondents into two groups. The first consists of those who at some time had indicated an interest in responding to future surveys. The other consists of those who had not so indicated, or who perhaps had so indicated at a much earlier time. The rate of response for the first group has been about 50 per cent, but for the second group it has been much lower. In general we could not detect a significant and systematic difference in the patterns of response of the two groups. For an idea of the distribution of respondents by size of firm, see table 2.

The *Fortune* survey has a number of serious drawbacks from the point of view of the analysis in which we are interested. To begin with, it is a mail survey, and we are faced, therefore, with the problem that the respondents are a self-selected special subgroup of the sample composing the mailing list, a sample, as we have already noted, itself difficult to classify.

Some tests have been made and some are still in progress to assess the possible bias that may be introduced by these characteristics of the survey. For one thing, we have reason to believe that the respondents consist of only those people who have fairly definite ideas about the large number of questions posed in the questionnaire. The major evidence consists of a comparison of the pattern of response to the *Fortune* questionnaire with that to the Dun & Bradstreet survey, to be discussed later.

In the case of the *Fortune* survey the rate of total nonresponse is fairly large, but among those who respond the rate of refusal on individual questions is fairly low; for instance, the rate of refusal on the question about expected sales in the respondents' own firm has been in the order of 1 per cent, and on the questions relating to general business conditions it has been only slightly higher, around 3 per cent. On the other hand, the Dun & Bradstreet survey, which involves personal interviews, frequently shows a high rate of nonresponse on individual questions. For instance, on the question about expectations of sales for the respondent's own firm the rate of refusal runs from 20 to 30 per cent, and for general business expectations as high as 50 per cent.

Thus one might suspect that the *Fortune* questionnaire gives us mainly the expectations of those who have well-defined opinions on general business conditions. Whether this involves a systematic bias is something that will be touched upon later.

Another attempt to determine the possible bias due to the selfselection of the respondents was based on an analysis of the struc-

TABLE 2

Size of Firm as Measured by Number of Employees, by Industry, *Fortune* Survey, May 1950

Number of Employees	*Capital Goods*	*Hard Consumer Goods*	*Soft Consumer Goods*				*Mining and Oil Extraction*	*Wholesale Trade*	*Retail Trade*	*Utility*
			All	*Food and Beverages*	*Textiles and Leather*	*Other*				
				Per Cent						
Under 50	5	5	7	5	5	9	10	21	12	2
50 to 99	7	8	7	9	5	6	2	14	12	4
100 to 499	36	33	33	29	35	33	22	41	33	15
500 to 2,499	28	29	28	27	36	25	25	14	22	39
2,500 and over	24	25	25	30	19	27	41	10	21	40
				Number of Respondents						
	541	492	650	189	204	269	122	252	273	127

Source: Compiled from data of *Fortune* magazine.

ture of response by speed of response. It has been suggested that, under certain conditions, the opinions of late respondents would tend to be closer to the opinions of nonrespondents than to those of prompt respondents.[2] This analysis gives us some indication that prompt respondents tend to be somewhat more optimistic than the average in the generally pessimistic surveys, and somewhat less optimistic than the average in the generally optimistic surveys. This might suggest that people who feel that their views run counter to the dominating views have a greater inclination to respond than others. The effect of such a reaction would be to yield a sample average expected change that is closer to zero than the population average, and also to produce a sample variance greater than the population variance (since the sample frequency around the mean would tend to be relatively smaller than the population frequency). However, the evidence suggesting this type of bias is by no means conclusive.

Another serious drawback of the *Fortune* survey is that some of the questions are not formulated with sufficient precision for the purpose of our analysis. An important instance is the question relating to expected sales. In the survey of May 1950 the question reads: "What are you expecting for the second half of 1950 in making plans for *your own firm*? Compared to the first half, which of the following are you expecting as far as your gross sales (or total revenue) are concerned?

A sharp increase (15% or more)
A moderate increase (between 5% and 15%)
No appreciable change (plus or minus 5%)
A moderate decrease (between 5% and 15%)
A sharp decrease (more than 15%)
No estimate."

The corresponding question in other surveys has been formulated in a similar fashion.

The above question does not indicate whether the reply should be made on a seasonally adjusted basis. Our analysis of the responses to this question, together with the facts that many other questions in the *Fortune* questionnaire specifically instruct the respondents to give a seasonally adjusted answer and that none instructs him to the contrary, suggests that the respondents tend to give a seasonally

[2] Robert Ferber, "The Problem of Bias in Mail Returns: A Solution," *Public Opinion Quarterly*, winter 1948-1949.

adjusted answer. In our analysis we have usually so assumed. However, it is clear that this lack of precision may be a serious source of error.

Another serious difficulty is that the respondent is not asked to quantify his answer freely but is given instead a fivefold choice of answer, as illustrated in the question quoted above. For the type of analysis we intend to carry out it would be desirable to describe the frequency distributions of the answers in terms of more conventional parameters such as some measure of central tendency and of dispersion.

In the early stages of our work we seemed to have some evidence that the expectations reported in the surveys then available might constitute a random sample drawn from a normally distributed population. When the cumulative distribution of the replies to a given question was graphed on normal probability paper, using as class limits the figures given in parentheses after each of the optional answers, the points tended to lie very close to a straight line. Standard tests of significance indicated that the discrepancies of the observed distribution from a normal distribution were not significant at the 5 per cent level. This suggested that the distribution could be characterized by the two parameters of the normal distribution, the arithmetic mean and the standard deviation. These two parameters were obtained by fitting a normal distribution to the observations by means of a modified maximum likelihood approach.

Unfortunately, this approach had to be discontinued. For recent surveys the hypothesis of normality cannot be reasonably maintained. This result is partly associated with the fact that the average expected change tends to differ more markedly from zero in the recent surveys than in those we first analyzed. It appears that the frequency distribution is approximately normal when the average is around zero, but that normality no longer holds when the average is sizably different from zero. In the latter case, at least for the *Fortune* respondents, the curve becomes skewed, with the longer tail extending to the left when the average is positive and to the right when it is negative.

The above phenomenon poses some interesting questions concerning both the structure of expectations and the influence of the form of a question on the response. These problems are, however, beyond the scope of this paper. It will suffice to indicate that we have been forced to drop our original method of estimating central tendency and dispersion in favor of one that makes much less restrictive assumptions as to the nature of the frequency distribution of the response. Our present measure of average expected percentage change is a normally interpolated median estimated by graphic methods, and our measure of dispersion is the semi-interquartile range with the quartiles also estimated by normal interpolation. Although there is no solid theoretical foundation to support this method as against many possible alternative procedures, the measures described are at least simple and economical to compute.

The details of the procedure are illustrated by chart 1, which shows the estimated average expectation and dispersion of the *Fortune* respondents in the durable goods industries in surveys 23

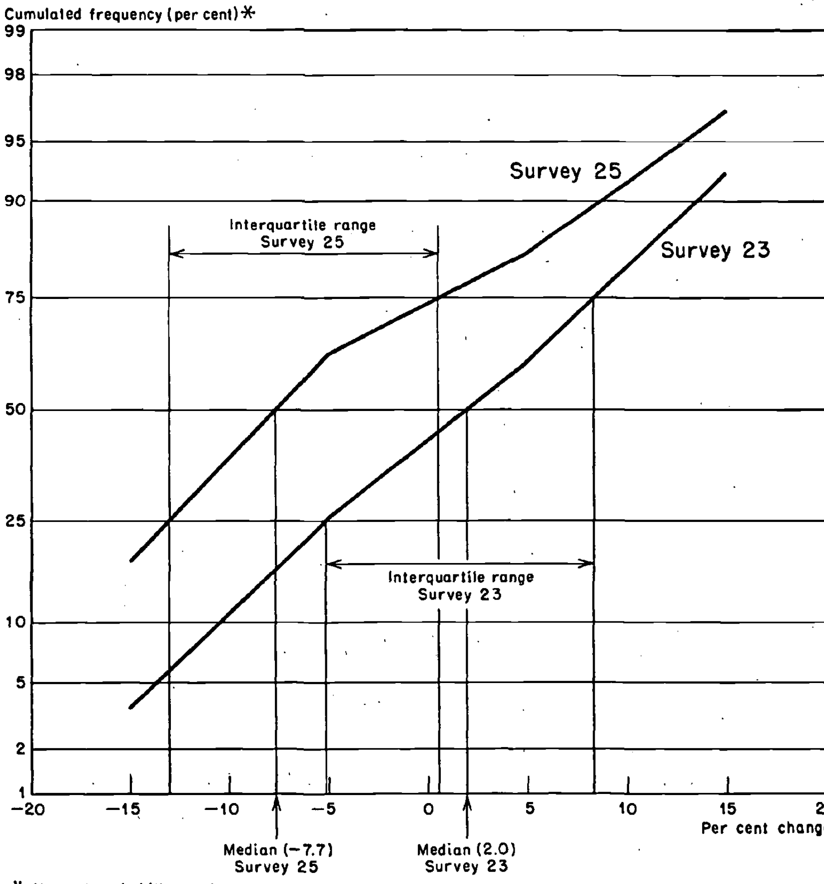

Chart 1. Computation of Median Expected Change in Sales, Durable Goods Industry, Two *Fortune* Surveys, May 1948 (Survey 23) and May 1949 (Survey 25)

and 25, conducted respectively in May 1948 and May 1949. First, the four obtainable points on the cumulative distribution are graphed on normal probability paper in the manner described earlier. Next, we locate the two points between which the median falls, and join them by a straight line. The abscissa of the point at which this line intersects the 50 per cent line is our estimate of central tendency, which we refer to as the average expected change.

To locate the first and third quartiles we proceed as above, using the points between which the first and third quartiles respectively fall. Our measure of dispersion is one-half the difference between the third and first quartiles. Thus in the chart presented the average is estimated at +2 per cent for survey 23, and —7.7 per cent for survey 25. The third quartiles are respectively at 8 per cent and 0.5 per cent, and the first quartiles at —5 per cent and —13 per cent. The dispersions are therefore equal to 6.5 per cent for survey 23 and 6.75 per cent for survey 25.

The reader will observe that the points plotted on the chart from survey 23 lie on a fairly straight line, which intersects the 50 per cent line at +2 per cent, i.e. rather close to zero. On the other hand, the points plotted from survey 25 do not approximate a straight line, and the curve passing through them intersects the 50 per cent line at about —8 per cent, i.e. some distance from zero. In general all the data from the surveys tend to exhibit such characteristics. The cumulative frequency distributions that yield an estimate of a median rather close to zero tend to approximate a straight line when plotted on normal probability paper, indicating a distribution fairly close to normal. Distributions that yield an estimate of a median *not* close to zero, on the other hand, do not fall on a straight line when similarly plotted, indicating a departure from normality.

It will be noted, further, that our measure of central tendency is an unweighted average, with no allowance for differences in the size of the respondents' firms. In other words, data from large and small concerns receive the same weight in the averaging process.

The reason for the above procedure relates to another drawback of the *Fortune* survey: except for the last two surveys the questionnaire did not solicit any information indicating the size of the respondent's firm. It was only in the surveys conducted in November 1949 and May 1950 that the respondents were asked the question, "Approximately, how many employees does your company have?" A frequency distribution of the response to this question for those industries in which we are presently interested was given in table 2 above for the survey conducted in May 1950.

An analysis of cross tabulations by size of firm of the responses to the most important questions on expectations does not reveal any evidence of correlation between size of firm and average expectations. This point is illustrated in table 3, in which we show the distribution of the replies to the questions on expected change in gross sales for four different size groups, for the survey of May 1949. In table 4, we exhibit our measure of average expected changes and of dispersion for each size group. There obviously is no systematic relation between average expected change and size, although there are some indications that the dispersion of expectations is negatively correlated with the size of firms. Similar results were found for the survey conducted in May 1950. This lack of correlation between size of firm and average expectation is broadly confirmed by our analysis of the returns of the Dun & Bradstreet survey.

The above considerations lead us to hope that our inability to weight firms by size when we compute the average expected change does not lead to serious bias in the estimate, although direct evidence to this effect is available only for the last two of the *Fortune* surveys.

3. Dun & Bradstreet, Survey of Business Trends and Business Expectations

Surveys of business expectations were first conducted by Dun & Bradstreet in the spring of 1947 and in the spring of 1948. From April to November of 1949 the surveys were on a monthly basis, and from November 1949 to date they have been conducted on a quarterly basis.

This survey avoids the problem of seasonality by asking the respondents to state their expectations and experiences in terms of change relative to the corresponding period of the year before. The time-frame of reference, however, has changed from survey to survey, being sometimes the whole year, sometimes a half year, and sometimes a quarter. This is a serious source of lack of comparability with the *Fortune* survey, and more will be said on this matter later.

The Dun & Bradstreet questionnaire is administered by personal interview, and the number of respondents has usually been about 1,000. The sample is drawn from a list of approximately 54,000 firms, which are regularly visited by Dun & Bradstreet interviewers col-

TABLE 3

Expected Changes in Sales Tabulated by Size of Respondent's Firm, *Fortune* Survey, November 1949

Number of Employees	*Number of Respondents*	*Percentage of Firms Expecting:* *Sharp Increase (+15% or More)*	*Moderate Increase (+5% to +15%)*	*No Appreciable Change (+5% to −5%)*	*Moderate Decrease (−5% to −15%)*	*Sharp Decrease (−15% or More)*	*No Estimate*
Under 100	831	6	31	33	24	5	1
100 to 499	1,103	6	31	35	22	5	1
500 to 2,499	943	6	31	34	26	3	—
2,500 and over	669	3	34	37	23	2	1
Not stated	255	4	29	36	24	5	2
All firms	3,801	5	31	35	24	4	1

Source: Compiled from data of *Fortune* magazine.

TABLE 4

Average Expected Change in Sales, All Respondents, by Size of Firm, *Fortune* Survey, November 1949
(*per cent*)

Number of Employees	*Average Expected Change in Sales*	*Dispersion*
Under 100	1.5	7.2
100 to 499	1.4	6.7
500 to 2,499	1.5	6.8
2,500 and over	1.4	6.0

Source: Compiled from data of *Fortune* magazine.

lecting information on their financial status. For further details the reader is referred to the various releases issued by Dun & Bradstreet (see, for instance, the release dated June 29, 1949).

On the whole the Dun & Bradstreet survey covers firms of appreciably smaller size than does the *Fortune* survey. (Compare the figures in column 3 of table 5 with those in the last row of table 3.) The size of the firms in each class shown in table 3 is reasonably comparable with the size of the firms in the corresponding class in table 5, where the measure of size is the volume of yearly sales, since yearly sales per employee in manufacturing industries were in the order of $13,000 during the years 1948 and 1949.

Our analysis of the Dun & Bradstreet data is not as advanced as our analysis of the *Fortune* survey. At the very start of this study

TABLE 5

Frequency Distribution, by Size of Yearly Sales, of Manufacturing Firms Responding to Dun & Bradstreet Survey, August 1949

Yearly Sales (thousands of dollars)	*Number*	*Per Cent of Total Reporting Sales*[a]
Under 500	139	33.7
500 but less than 1,000	107	26.0
1,000 but less than 5,000	123	29.9
5,000 but less than 30,000	34	8.3
30,000 and over	9	2.2
Total reporting sales	412	100.0
Respondents not reporting sales	169	
Total	581	

[a] The figures are only approximate as they are derived from frequency distributions whose class limits do not exactly coincide with those used in this tabulation.

Source: Compiled from data of Dun & Bradstreet.

Fortune generously gave us all of their survey data in the form of IBM cards. Later we worked out a plan with Dun & Bradstreet to secure the tabulations we needed to carry out the type of analysis in which we are interested. A special plan was necessary because the Dun & Bradstreet respondents, unlike the *Fortune* respondents, are individually identified, and the collecting agency is, of course, careful not to supply any information that might enable us to identify the respondents. So far, therefore, we have been able to analyze only a fraction of the Dun & Bradstreet data.

Further details of the Dun & Bradstreet survey are best given in connection with the analysis presented below, especially section C 2.

C. *How Well Do Firms' Anticipations Forecast Sales?*

1. The interwar period

The forecasts of the Shippers' Advisory Boards are the only data we have been able to analyze for the purpose of testing, for the interwar period, the ability of firms to forecast sales.

As indicated previously, the shippers' forecasts have been collected on a systematic basis since the middle of 1927. Thus we have at our disposal forecasts for nearly 100 quarters for 32 different individual commodities in 13 different regions. Furthermore, these data are very suitable for a comparison with the actual course of events because the same source that collects the forecasts also supplies us with exactly comparable statistics of the actual course of shipments. We can ascertain, therefore, how well the shippers' anticipations have performed in forecasting the actual course of carload shipments in the following quarter. In the present section we shall deal only with the interwar period, which consists of 58 quarters beginning with the third quarter of 1927 and ending with the last quarter of 1941. For reasons that will become apparent the postwar period will be analyzed separately, together with the data on anticipations provided by other sources.

There are a great number of possible methods by which the shippers' anticipations might be tested for forecasting accuracy. Furthermore, any given method could be applied to the aggregate of all commodity groups or regions, or to individual commodity groups, or to individual regions. A systematic analysis of this type is presented by Robert Ferber in "The Railroad Shippers' Forecasts," in *University of Illinois Bulletin 74*, June 1953. We shall present here only some of the most significant results.

The first test we present is based on analysis of the error of forecast. For any given commodity or quarter the percentage error of forecast is defined as the difference between the shippers' forecast, E_t, and the actual number of carloads, A_t, expressed as a percentage of the actual number of carloads, i.e.

$$100\frac{E_t - A_t}{A_t}$$

Two tests based on this quantity are shown in table 6. In column 2 we show the simple arithmetic average of the percentage error of forecast for all manufactured commodities taken together and for certain industries taken separately. It will be observed that for all manufactured commodities, in the prewar period, 1927-1941, shippers tended on the average to overestimate shipments by some 4 per cent. This tendency to overestimate on the average holds also for individual commodities with but one exception. The entries in columns 3, 4, and 5 show the mean ratio for groups of quarters according to the trend of actual shipments. A given quarter is classified as "rising" when actual carloads in that quarter were more than 5 per cent higher than in the corresponding quarter of the year before; it is classified as "falling" if shipments were more than 5 per cent below the corresponding quarter of the year before; it is classified as "level" otherwise.[3]

It will be seen that shippers tend to overestimate carloads markedly when shipments are falling, the average overestimate being as high as 16 per cent. On the other hand, when shipments are rising the average error is negative, indicating that shippers tend then to underestimate shipments, although the error is in this case considerably smaller. This same pattern is repeated for every one of the five individual industries for which data are shown in table 6.

The comparison of means by trends of carloadings is interesting because it suggests immediately a definite tendency for anticipation to lag behind actual events. It is clear, in fact, that if anticipations lag behind shipments, they will tend to overestimate when the trend is down and underestimate when the trend is up.

It will be further noted that, at least for all manufactured commodities, when the trend in shipments is "level" the average error is exactly zero. This result suggests that the overall tendency for

[3] The trend is defined in terms of the corresponding quarter of the year before to eliminate the necessity of an explicit seasonal adjustment. Though this method is crude, experiments with more refined methods have given essentially the same results.

TABLE 6

Measures of Error of Shippers' Forecasts, 1927-1941 and 1946-1950

Commodity (1)	Average Percentage Error[a]				Average Absolute Percentage Error		Coefficient of Relative Accuracy (8)
		By Trend of Carloadings					
	All Quarters (2)	Rising Quarters (3)	Level Quarters (4)	Falling Quarters (5)	Shippers' Forecasts (6)	Naïve Model (7)	
	1927-1941						
All manufactured commodities	+4	−5(23)	0(13)	+16(22)	10.0	8.3	−0.20
	1927-1941 and 1946-1950				*1927-1941*		
Iron and steel	+7	−10(40)	−11(5)	+29(33)	20.5	18.8	−0.09
Agricultural implements	+7	−8(42)	+6(9)	+30(27)	21.0	20.3	−0.03
Cement	+4	−8(32)	+7(19)	+16(27)	12.4	9.8	−0.26
Lumber and forest products	+7	−8(35)	+5(11)	+22(32)	15.2	9.8	−0.55
Flour, meal, etc.	+2	−7(23)	+2(36)	+11(19)	6.5	6.2	−0.05
	1927-1941 and 1946-1950						
Machinery and boilers	+8				18.2		
Automobiles, trucks, and parts	+8				17.8		
Chemicals, etc.	+1				10.8		
Paper, etc.	−2				12.1		
Petroleum products	+3				7.2		
Brick and clay products	+8				15.5		
Canned goods food products	+2				11.2		
Total nonfarm[b] carloadings	+4				9.0		

[a] Overestimates indicated by plus sign; underestimates indicated by minus sign; figures in parentheses give the relevant number of observations.

[b] Includes all commodities listed in table 1 and also "coal and coke" and "ore and concentrates."

Source: Compiled from data of regional Shippers' Advisory Boards, Association of American Railroads.

anticipation to overestimate shipments in the period observed may not be due so much to a systematic upward bias as to the tendency to overestimate shipments when they are falling, coupled with the overall declining trend of carloadings in the period.

The mean errors that we have been discussing are primarily useful as a measure of systematic bias but are otherwise not very illuminating as a measure of accuracy of forecasts.

Clearly, in an arithmetic average, errors of opposite sign offset each other, so that the average may be close to zero even though the individual errors are large. A more revealing measure of accuracy can be secured by averaging the errors without regard to sign, i.e. by computing the average absolute percentage error of forecast. This statistic is shown in column 6 of table 6. It begins to be apparent from the figures in this column that the shippers' anticipations have not been too accurate in forecasting shipments. For all manufacturing industries the forecast was, on the average, in error by as much as 10 per cent, a significant figure if one considers that the shippers are forecasting only one quarter ahead. With the exception of the flour and petroleum industries the record is even poorer for individual commodities; for iron and steel and agricultural implements, for instance, the average error exceeds 20 per cent.[4]

While the figures we have just examined indicate that the shippers' forecasts tend to err by substantial margins, it is difficult to evaluate this result unless we have some standard against which to measure the shippers' performance. Clearly, an average forecasting error of 10 per cent may be serious for a series that exhibits only very small movements from quarter to quarter, but not for a series subject to violent short-term changes. We may suspect that this basic variability probably has a good deal to do with the marked difference in the forecasting record of individual industries. To throw light on this subject it will be useful to compare the error of the shippers' forecast with the error that might have been made by the use of some simple and mechanical extrapolation formula. This procedure is what has been called in recent discussions a "naïve model" test.

The simplest type of naïve model that has been suggested is to

[4] The years 1946-1950 were included in computing the average absolute error for the last eight items in table 6, since a separate analysis of these industries is not given for the postwar period. The inclusion of the sixteen postwar quarters does not affect the picture significantly.

forecast by extrapolating either the latest level or the latest rate of change. This yields a forecasting formula of the type

$$X_{t+1} = X_t \text{ ; or } X_{t+1} = X_t + (X_t - X_{t-1})$$

These models, which are quite satisfactory for yearly data, are not immediately applicable to our case, however, because of the strong seasonal components in all series. Obviously, even naïve models need not ignore the presence of seasonal variation. On the other hand, it does not seem reasonable to introduce an explicit seasonal adjustment factor computed by means of standard statistical techniques, as the use of these techniques would hardly be consistent with the notion of a naïve model test. We have made use, therefore, of a very simple model that does not require explicit adjustment for seasonal variation and seems to be extensively used by people not familiar with more sophisticated techniques. In this we assume that if in the first quarter there was, say, a 5 per cent increase over the first quarter of the previous year, the same thing will happen in the second quarter.

The specific model we have used is represented by the equation

$$(1) \qquad A_t^c = \frac{A_{t-4}A_{t-1}}{A_{t-5}}$$

A_t^c denotes here the naïve model forecast for quarter t; A_{t-4} is the actual quantity for the same quarter of the year before; and A_{t-1}/A_{t-5} represents the adjustment for the change that has occurred in the course of the year ending at the point where the forecast is made, namely the quarter $t-1$.

The question we want to test is whether the shippers' forecasts are any better than the forecasts that can be made by use of this formula. For this purpose we have computed the average absolute percentage error which would have resulted by forecasting the coming quarter according to this formula. This "naïve model error" is clearly measured by the quantity

$$(2) \qquad \frac{1}{N}\sum 100 \left| \frac{A_t^c - A_t}{A_t} \right| = \frac{100}{N}\sum \left| \frac{A_{t-4}A_{t-1}}{A_{t-5}A_t} - 1 \right|$$

where N indicates the number of forecasts included in the test.

The naïve model error for total manufactured commodities and for five selected commodities is shown in table 6, column 7. It should be noted that, by the very nature of our naïve model, the figures of column 7 may also be taken as a measure of variability in the series forecast, arising from factors other than seasonal variation and possibly exponential trend. If the only source of variation consisted of the recurrent seasonal and an exponential trend, we should have

$$\frac{A_t}{A_{t-1}} = \frac{A_{t-4}}{A_{t-5}} \text{ and, therefore, } \frac{A_{t-4}A_{t-1}}{A_{t-5}A_t} - 1 = 0$$

The naïve model error of column 7 would therefore be zero. Hence the larger the figures of column 7, the larger must tend to be the variability, other than seasonal and trend, of the given series.

A comparison of the figures in column 7 with the average absolute shippers' error shown in column 6 reveals immediately two significant facts: (a) There is a close positive association between the two sets of figures, indicating that the differences in the forecasting accuracy for individual commodities are largely controlled by the short-term variability (other than seasonal and trend) in the shipments of the commodity. (b) For every individual commodity, as well as for all manufactured commodities, the error of the shippers' forecasts exceeds the error of the naïve model. In other words, for every one of the commodities sampled in table 6 the forecast based on the naïve model of formula 2 would have resulted on the average in an error smaller than that made by the respondents to the shippers' survey.

A third observation suggested by the comparison of columns 6 and 7 is that the ranking of the commodities in order of accuracy indicated by column 6 is considerably changed when we take into account the difficulty of forecasting due to the underlying variability of the series. This point is brought out clearly by the "coefficient of relative accuracy" in column 8. This coefficient is obtained by subtracting the figure of column 6 from that of column 7 and expressing the result as a percentage of the figure of column 7. The coefficient, therefore, measures the relative superiority (if positive) or inferiority (if negative) of the respondents' forecasts compared with the naïve model.

If the respondents had made a perfect forecast in every single instance, the figure of column 6 would be zero and our measure of relative accuracy would become unity; this is the highest value that the coefficient can take. If the figures of columns 6 and 7 are equal, the coefficients will take the value zero, indicating that the forecast made with the naïve model is just as good as the respondent's forecasts. Finally, if the average forecasting error of the respondents exceeds that of the naïve model, as in the present instance, the coefficient in column 8 will be negative and will take any value up to minus infinity. We see from column 8 that according to this measure of accuracy, flour, meal, etc. and agricultural implements rank highest, while lumber and forest products ranks lowest with an average error more than 50 per cent larger than that of the naïve model. For all manufactured commodities together, the shippers' error is some 20 per cent larger than that of the naïve model—an amazingly high figure.

The rather negative results we have reached so far with respect to the forecasting record of the shippers' survey are further confirmed by our third and last test. Instead of comparing the forecasted with the actual *level* of shipments, we shall compare the forecasted with the actual rate of quarter to quarter change in shipments; more specifically, we shall examine whether there exists a significant positive correlation between these two series, i.e. between E_t/A_{t-1} and A_t/A_{t-1}. This test has one important point in common with the test we have just described. If we find that the correlation between the actual and anticipated rates of change does not differ significantly from zero, that fact will imply that the shippers' forecasts are no better on the average than a forecast of "no change." Hence the size of the correlation coefficient represents a measure of the extent to which the shippers' forecasts are better than a naïve model that forecasts no change at every point of time.

The present test differs, however, from the previous one in that we are now giving the respondents the benefit of any constant bias in their forecast. Suppose, for instance, that the respondents always underestimate the actual rate of change by a constant amount; under this condition every one of the forecasts would be in itself erroneous. The average error of column 2 might be large and the coefficient of column 8 might not be much larger than zero or even negative; nonetheless, the correlation between the actual and expected rates of change would be unity, since the actual and anticipated rates of change would differ by a constant amount. Generally, the respondent's bias might involve not only a constant but also a multiplicative factor, because, if the actual rate of change were any linear function of the anticipated rate of change, the two series would be perfectly correlated. On the other hand, the average error of column 2 would be zero only if this linear function were characterized by a zero constant term and a slope of unity.

It will be recognized that a test based on the correlation of the actual and anticipated rates of change is primarily an answer to the second of the two questions we have raised as to the forecasting value of anticipations. Our first question, it will be remembered, was whether anticipations represent good forecasts, per se. The tests we have described earlier have been aimed at throwing light on this question. Our second question was whether one might, through some simple manipulation, utilize the respondents' anticipation for a direct forecast of the variable covered by the anticipation. The correlation tests, the result of which we are about to report, will at least partly answer the second question; it is clear that a high correlation between the actual and anticipated rates of change would indicate that we might secure a good forecast of the actual rate of change by basing our forecast on a function of the anticipated rate of change—in this case a linear function. The parameters of this linear function would be simply the parameters of the regression equation.

In carrying out this test we must, unfortunately, cope with the vexing problem of seasonal variation in the data. Clearly, the ratio A_t/A_{t-1}, being the ratio of two consecutive quarters, is affected by seasonal variation, which is marked in our data. Hence if we proceeded to correlate E_t/A_{t-1} with A_t/A_{t-1} without any adjustment for seasonal change, we might well find a sizable positive correlation arising simply from the fact that the shippers are able to estimate, within reasonable limits, recurring seasonal changes. What we want to know, however, is whether they are able to forecast changes other than those arising from recurring seasonal fluctuations.

There are two ways in which we could handle the problem of seasonal variations. The first method would be to adjust the data on shipments and on anticipations for seasonal fluctuation and then correlate the seasonally adjusted actual rate of change with the seasonally adjusted anticipated rate of change. The main drawback of this method is that there is at present no simple and reliable method for carrying out the seasonal adjustment. The existing methods are laborious and/or open to logical objections. They involve considerable manipulation of the data, and the extent to which such manipulations affect the results is frequently difficult to assess.

A second method available to us, and not open to the above objections, is to separate the original fifty-eight observations into four groups, according to the quarter of the calendar year to which each observation refers, and to correlate each group separately. By this means we avoid the difficulty of adjusting for seasonal variation, since each observation for any group will have the same seasonal factor entering into it (assuming that this seasonal factor itself does not change significantly from one year to another). The major drawback of this technique is the loss of efficiency due to the severe reduction in the degrees of freedom. For our present purposes, however, since we have some thirteen or fourteen observations for each of the four groups, we can probably afford this loss. We have, therefore, followed this method primarily, though some checks have been carried out using the more conventional method of adjustment for seasonal variation.

In table 7 we present the results of the test for the aggregate of all manufactured commodities and for three selected industries, iron and steel, cement, and lumber and forest products. In no case is

TABLE 7

Correlation of Actual and Anticipated Rates of Change of Sales for Selected Commodity Groups, Shippers' Survey, 1927-1941

Quarter	*All Manufactured Commodities*	*Iron and Steel*	*Cement*	*Lumber and Forest Products*
First	−0.13	−0.09	−0.429	0.05
Second	−0.23	−0.31	0.27	−0.28
Third	−0.43	0.07	0.38	−0.34
Fourth	0.44	0.14	0.52	−0.24
All quarters	−0.01	−0.04	0.19	

Source: Compiled from data of regional Shippers' Advisory Boards, Association of American Railroads. The 5 per cent level of r is 0.55 for the first quarter, which is based on thirteen observations, and 0.53 for the remaining three quarters, which are based on fourteen observations.

the correlation significantly different from zero at the 5 per cent level of significance and in more than half of the instances it is even negative. In the last row of the table we present the correlation coefficients secured by adjusting the data for seasonal variation[5] and combining all the quarterly observations. The correlations are, again, close to zero. In other words, the shippers' survey appears to be of little use in forecasting the rate of change of shipments.

In order to get a better understanding of the significance of these results, it is worth pointing out that if instead of correlating the

[5] The rather crude seasonal adjustment used consists of dividing each observation E_t/A_{t-1} for a given quarter by the average value of A_t/A_{t-1} for that quarter. The latter ratio, it will be seen, provides a rough estimate of the normal seasonal change from quarter $t-1$ to quarter t.

actual with the anticipated rate of change we correlate the actual with the anticipated *level* of shipments, we get strikingly different results. These correlations are, in every case, very high; in the case of the four industries of table 7 they range from a minimum of 0.86 for iron and steel to as high as 0.965 for cement. The results of table 7 show that this high correlation between actual and forecast levels is fully accounted for by the high serial correlation and by the sharp, recurring seasonal fluctuations that characterize our quarterly data over the period of observation. Once we eliminate the influence of these two factors, we find that the shippers' anticipations have little to offer as a direct forecast of future shipments.

In conclusion, our analysis indicates that the shippers' anticipations did not provide, in the interwar period, very accurate forecasts of shipments, and that simple mechanical extrapolation models would have done, on the whole, no worse than a forecast based on the shippers' survey.

2. The postwar period

Several considerations make it desirable to analyze the interwar and postwar periods separately. In the postwar period we have, in addition to the shippers' forecast, the two other sources of data on anticipations described in section B; hence it is clearly desirable to compare the behavior of these series over the overlapping period. In addition the postwar years constitute, undoubtedly, a rather abnormal period, with characteristics different from those of the interwar period; it is conceivable, therefore, that the forecasting value of the shippers' anticipations might be considerably affected. Differences might also occur because the quality of the shippers' forecasts might have improved (or deteriorated) in time.

A systematic comparison of data from the three sources is difficult because of the differences in the nature of the surveys, and especially because of differences in the form of the questions. As far as we have been able to ascertain, the Shippers' Advisory Board procedure was essentially the same in the postwar as in the prewar period, so no new problem arises there. The *Fortune* and Dun & Bradstreet surveys, on the other hand, impose the additional problem of securing data from outside sources in order to test the accuracy of their forecasts. One other complication arises in connection with the Dun & Bradstreet survey: the length of the period forecast by the respondents has varied from time to time.

Another important difference in the three surveys is in their coverage. The shippers' forecasts included in our analysis refer only to certain manufactured commodities. The survey of Dun & Bradstreet, on the other hand, covers all manufacturers, retailers, and wholesalers, but our analysis is limited to retail trade and manufacturing industries. The *Fortune* survey has still broader coverage, including, in addition to the types of activity already mentioned, finance, transportation, public utilities, service industries, construction, advertising, radio, and publishing. Of these, only the following will be covered in this analysis: manufacturing, wholesale and retail trade, and, to a minor extent, mining and utilities.

Because of the differences in the nature of the surveys, it is not possible to apply the same procedure to every source. We have tried, however, as far as possible, to apply to all data the same general types of test that were applied in the previous section to the shippers' data.

The first test consists in analyzing the behavior of the percentage error of forecast; the results are reported in table 8. The measures given in columns 3 to 7 are the same as those presented for the interwar period in table 6 and were computed according to the procedure described above. The only difference is that periods of "level" and "falling" activity have been lumped together, there being too few observations to compute meaningful separate means.

The similarity between the first row of part A of table 8 and the comparable first row of table 6 is striking. As in the interwar period, the forecast tended on the average to overestimate shipments slightly. This tendency is concentrated in quarters in which shipments were level or falling. In quarters of rising shipments, on the other hand, we observe an underestimate of the same order of magnitude. The average absolute percentage error, shown in column 6, is somewhat smaller than in the interwar period. This decline appears, however, to be due primarily to the fact that in the postwar period shipments exhibited less pronounced fluctuations than they did in the thirties. This is brought out by the value of the absolute percentage error of the naïve model, an error which, it will be recalled, is basically a measure of the variability of the series being forecast.

For purposes of our naïve model test we found it necessary to eliminate the first seven postwar quarters, since during the war and until the end of 1945 the classification used by the shippers' survey was different from that used in the interwar period and reintroduced in the first quarter of 1946. In addition, shipments in the first quarter of 1946 were seriously affected by the strike in the

TABLE 8

Measures of Errors of Business Anticipations in the Postwar Period, 1946-1950

Period Covered[a] (1)	Commodity or Industry (2)	*Average Percentage Error of Forecast*[b] All Periods[c] (3)	Periods of Rising Activity[c] (4)	Periods of Level or Falling Activity[c] (5)	*Average Absolute Percentage Error of Forecast* Survey (6)	Naïve Model (7)	Coefficient of Accuracy[b] (8)	Correlation of Actual and Anticipated Rates of Change (9)
	A. Shippers' Forecasts[d]							
IQ 1946 to IVQ 1950	All manufactured commodities	0.9(20)	−5.9(9)	6.5(11)	6.2			
IIIQ 1947 to IVQ 1950	All manufactured commodities	2.4(14)			6.6	5.4	−0.22	
IQ 1946 to IVQ 1950	Cement	(20)			9.7	10.4	0.08	
IQ 1946 to IVQ 1950	Lumber and forest products	(20)			10.7	10.3	−0.03	
IQ 1946 to IVQ 1950	Flour, meal, etc.	(20)			6.2	7.8	0.21	
IQ 1946 to IVQ 1950	Agricultural implements	(20)			13.1	11.3	−0.16	
	B. Fortune Surveys[e]							
IIH 1947 to IIH 1950	Durable manufactures	−7.0 (8)	−9.0(6)	0.0 (2)	7.3	9.4	0.23	0.80
IIH 1947 to IIH 1950	Nondurable manufactures	−4.0 (8)	−6.0(5)	0.0 (3)	5.4	5.9	0.08	05.4
IH 1948 to IIH 1950	Wholesale trade	−4.0 (7)	−8.0(4)	1.0 (3)	6.0	6.1	0.01	

TABLE 8 (continued)

Period Covered[a] (1)	*Commodity or Industry* (2)	*Average Percentage Error of Forecast*[b]: *All Periods*[c] (3)	*Periods of Rising Activity*[c] (4)	*Periods of Level of Falling Activity*[c] (5)	*Average Absolute Percentage Error of Forecast*: *Survey* (6)	*Naïve Model* (7)	*Coefficient of Accuracy*[b] (8)	*Correlation of Actual and Anticipated Rates of Change* (9)
IH 1948 to IIH 1950	Retail trade	–4.0 (7)	–6.0(4)	–2.0 (3)	4.9	4.1	–0.21	0.39
	Private sector, national income (implicit forecast)	–4.0 (8)	–5.0(6)	–1.0 (2)	4.5	5.5	0.20	0.64
	C. Dun & Bradstreet Surveys[e]							
IQ 1948 to IVQ 1950	Durable manufactures	–4.0 (8)	–17.0(4)	9.0 (4)	12.8	11.0	–0.16	0.03
IQ 1948 to IVQ 1950	Nondurable manufactures	–1.0 (8)	–7.0(4)	6.0 (4)	7.2	6.0	–0.19	0.10
IQ 1948 to IVQ 1950	Retail trade	–4.0 (7)	–6.0(4)	–1.0 (3)	3.8	3.8	–0.02	0.36

[a] IQ = first quarter, IH = first half, etc.
[b] Negative errors indicate underestimates, positive errors overestimates.
[c] Figures in parentheses indicate the relevant number of observations.
[d] Anticipations refer to carload shipments.
[e] Anticipations refer to dollar volume of sales.
Sources: Compiled from data of regional Shippers' Advisory Boards, Association of American Railroads; *Fortune* magazine; and Dun & Bradstreet.

automobile industry. Hence the first postwar quarter that could be used in the model was the second quarter of 1946. But the naïve model requires knowledge of A_{t-5} in order to forecast A_t; hence the first quarter that could be forecast by use of this model was the third quarter of 1947.

For the remaining fourteen quarters the average error of the naïve model is only 5.4 per cent, or about half as large as in the interwar period. For the same period the shippers' error of forecast, while sizably smaller than for the interwar period, is once more surprisingly larger than that of the naïve model. The coefficient of relative accuracy (column 8) shows, in fact, that the postwar forecasts are about as poor, on the basis of this test, as those of the interwar period.

In the remaining rows of part A of table 8 we give results of the naïve model test for selected industries. In general the forecasting record is significantly better than that shown in table 6, although the industry ranking according to accuracy remains approximately the same. Here, for the first time, we find some evidence of the shippers' forecasts performing better than a mechanical extrapolation formula. For flour, meal, etc. the margin is substantial.[6]

It may seem surprising that the record for each individual industry was better than for the aggregate of all industries. A similar phenomenon appeared to a lesser degree even in the interwar period, for, of the five selected industries, only one performed much worse than the aggregate, while three had a significantly surperior record. Intuitively, one might expect the opposite. It is easy to see how a substantial error for individual industries might be consistent with a small error for the aggregate since errors in opposite directions might cancel out in the aggregation process; but it is, at first sight, difficult to understand how relatively good forecasts of individual industries can be consistent with the poor forecast of the aggregate. One possible explanation is that the five industries that we selected have a better than average forecasting record. While this may partly be the case, it should be emphasized that the coefficient of relative

[6] For iron and steel the shippers' forecast also performed substantially better than the naïve model. This superiority may, however, be rather misleading because of the effects on the naïve model of the steel strike in the fourth quarter of 1949. For this reason the iron and steel industry was omitted from table 8. It might be noted in this connection that if, for agricultural implements, we eliminate the first five quarters, which were presumably seriously affected by reconversion problems, the shippers' error falls from 13.1 as shown in table 8 to only 6.7 and the coefficient of relative accuracy rises from —0.16 to 0.41.

accuracy of the aggregate might well be less than that of each component series. This possibility arises from the fact that individual components will typically exhibit greater variability than an aggregate. It should also be noted that to the extent that the agency conducting the shippers' survey is interested in the shipments of individual industries in individual regions, rather than in aggregate shipments of all industries, the survey may provide it with valuable information. Nonetheless, the analysis of the postwar record is further evidence that the shippers' expectations are of little use as a direct forecast of aggregate shipments.

Our analysis of the eight semiannual sales forecasts collected through the *Fortune* survey is given in table 8, part B. For each of the four individual industries listed, the ratio of forecast to actual sales, E_t/A_t, was computed by estimating the average expected change $(E_t/A_{t-1})-1$ (for method see above, section B 2), and dividing the resulting estimate of E_t/A_{t-1} by A_t/A_{t-1}, the actual change in sales.[7] Seasonally adjusted data were used for reasons given in section B 2 above. Our estimates of the average anticipated change in sales are reproduced in the Appendix. They are also shown in chart 2 (shaded bars), together with the actual change in sales A_t/A_{t-1} (black bars).

For the private sector of national income, which appears in the last row of part B of table 8, the anticipated rate of change was secured by a more complex procedure. First, the average anticipated rate of change was computed for two additional industries, mining and public utilities. Next, the average anticipated change for each of the six industries was weighted by the industry's contribution to national income. Data for 1949[8] were used, though the choice of any other year would not materially affect the results. Since the six industries covered accounted for nearly 60 per cent of national income produced by all private industries, the weighted average anticipation computed in this fashion can be regarded as a measure of the *implicit* anticipated change in the private sector of national income. (It should be noted that the *Fortune* respondents were also asked *explicit* questions as to their anticipation of change in gross national product. Our measure of implicit anticipated change in the private sector of national income should not be confused

[7] See *Survey of Current Business* (Department of Commerce), October 1950, p. 20, for data through 1949; current issues for data through 1950.

[8] As given in *Survey of Current Business, National Income Supplement* (Department of Commerce), July 1950, table 13, p. 15.

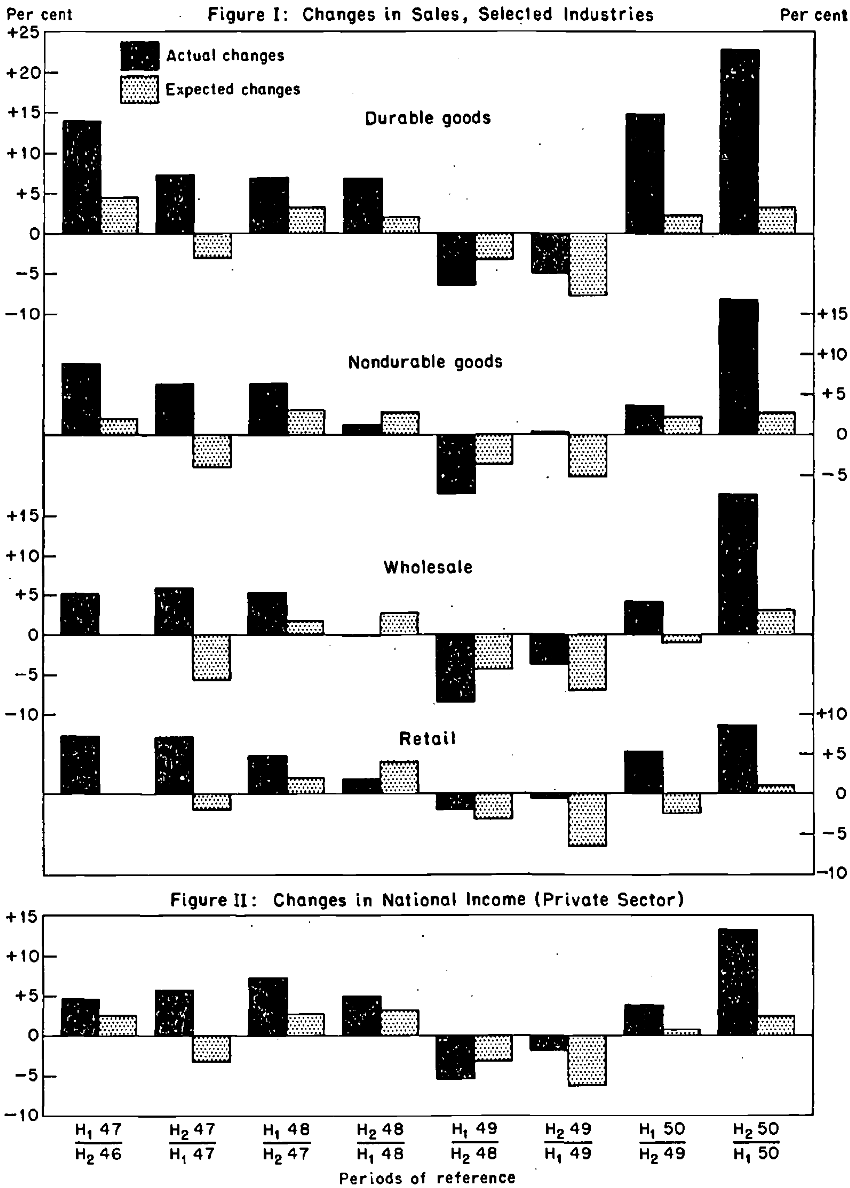

Chart 2. Average Actual and Expected Changes in Sales Reported in *Fortune* Surveys, and Changes in National Income (Private Sector), 1946-1950

with the average explicit anticipated change in gross national product.) This implicit anticipated change was then related to the actual change in the private sector of national income (seasonally adjusted).[9] The relationship is shown in figure II of chart 2.[10]

A cursory inspection of chart 2 will suggest that the forecasting record of the *Fortune* respondents is superior to that of the Shippers' Advisory Boards. In the entire record of eight forecasts for four individual industries, we note only one really serious failure, namely, the forecasts for the second half of 1947. For this period, respondents in every industry expected on the average a mild contraction, which definitely failed to materialize. Except for this failure, however, the record is rather respectable. It should be noted in particular that the anticipations for durable and nondurable manufacturing industries, as well as the implicit forecast of the private sector of national income, predicted correctly the *direction* of change in every one of the remaining seven semiannual periods. The correct forecast made early in November 1948 of a contraction for the first half of 1949 is especially worth noting, considering that sales in October 1948 were at an all-time peak and, in the case of durable goods, had been rising in the immediately previous month. Equally impressive is the forecast for the first half of 1950, made after sales had been falling in the immediately preceding months and while they were still generally falling.

At the same time it appears that throughout the postwar period the *Fortune* respondents tended to be too pessimistic. Not only did they forecast a contraction for the second half of 1947 that did not occur, but furthermore, on the average, they underestimated expansion in almost every instance in which expansion actually took place, and they overestimated contraction in several instances, notably for the second half of 1949.

These general impressions, suggested by chart 2, are confirmed by the more precise analysis of table 8, part B. First, turning to column 3, which shows the average percentage error of forecast for the whole period covered, we find that for every one of the

[9] It would have been desirable, also, to compare the implicit anticipated change with the actual change in national income originating in the six industries, but unfortunately the necessary national income information is not available on a semiannual basis.

[10] The anticipated change for the first half of 1947 is a crude estimate, not strictly comparable with the other estimates because the question of sales expectations was formulated in a somewhat different form; no information is available for mining; and wholesale and retail trade were lumped into a single category.

industries analyzed the error is negative, indicating an average underestimate. This underestimate was as high as 7 per cent for durable manufactures and 4 per cent for every other industry. It contrasts strangely with the average overestimate of 0.9 per cent which we find for the shippers' forecasts. Turning to columns 4 and 5, we observe again that in periods of rising activity the tendency to underestimate is pronounced. However, in periods of level or falling activity there is little tendency to overestimate. In fact the average error is remarkably close to zero, though there are too few observations to draw any reliable conclusions. The average absolute error of forecast shown in column 6 is appreciably smaller than we have tended to find for the shippers' survey, with the single exception of the durable goods industries. This exception is significant, however, since the shippers' survey is heavily weighted with durable goods. For retail trade, on the other hand, and for the private sector of national income, the error is only about two-thirds as large. Once more we may suspect that variations in the average error are related to the underlying variability of the series forecast, and this suspicion is, in fact, broadly confirmed by the naïve model test, as seen in columns 7 and 8.

Since we are now dealing with seasonally adjusted data, we are able to use a simpler naïve model than that used previously, namely, a simple extrapolation of the latest seasonally adjusted level. In other words, our naïve model forecast reduces to

$$A_t^c = A_{t-1} \tag{3}$$

The average absolute error of the naïve model is thus given by the formula below, where N denotes the number of surveys:

$$\frac{100}{N}\sum \left| \frac{A_t^c}{A_t} - 1 \right| = \frac{100}{N}\sum \left| \frac{A_{t-1}}{A_t} - 1 \right| \tag{4}$$

This error, which is shown in column 7, is therefore simply the average absolute semiannual rate of change. There is, clearly, a strong association between the average absolute error of respondents' forecasts and this measure. At the same time, as we should expect from our analysis of chart 2, it appears that the change anticipated by the respondents has been, in general, a better forecast than a simple extrapolation of the past. Indeed, the respondents' forecasts for the durable goods industries and their implicit forecast of the private sector of national income turn out to be some 20 per cent more accurate than the naïve model's. The only negative coefficient of accuracy is for retail trade. Although the respondents in this industry made the smallest average absolute error, the series they were forecasting was so stable in this period that an extrapolation of level would have yielded considerably more accurate forecasts.

For Dun & Bradstreet our tests were based on only eight of the sixteen surveys conducted to date by that agency. In order to maintain comparability with our other sources in terms of period covered, we have not included in our analysis the last three surveys, relating respectively to the first, second, and third quarters of 1951. We have also omitted the first survey, made in the spring of 1947, since it was based on a very small sample and in several respects is not comparable with later surveys. Of the twelve remaining surveys it appeared desirable to discard four additional ones because they were taken within a short period of time.[11] The eight surveys used are listed in table 9.

The ratios of expected to actual sales were secured, as for the *Fortune* data, by dividing the anticipated by the actual change. With minor exceptions the average expected change for these surveys is the unweighted median, as computed by Dun & Bradstreet and published in their releases.[12]

Since expected sales are reported as percentage changes relative to sales in the corresponding period of the year before, we compute the ratio of anticipated to actual sales, E_t/A_t, by means of this formula:

$$\frac{E_t}{A_t} = \frac{1 + e_t}{A_t/A_{t-4}} \tag{5}$$

[11] The inclusion in our analysis of every one of the four surveys conducted between April and June 1949 would give undue weight in the Dun & Bradstreet sample to anticipations formed in the second quarter of 1949. Of these surveys we have included, therefore, only the first and last, which were conducted roughly three months apart. Their timing agrees more closely with the shippers' and *Fortune* surveys. Surveys 7 and 9 were eliminated for analogous reasons.

[12] The exceptions are as follows: For survey 2 the average expected change for the two manufacturing industries represented is the unweighted arithmetic average computed from information supplied by Dun & Bradstreet. No corresponding information was available for retail trade and, therefore, for this industry, survey 2 is not included in the computations of table 8. Finally, for survey 13 the average expected change is an unweighted median estimated by us on the basis of incomplete information.

Here e_t is the average expected change and A_t and A_{t-4}, respectively, denote actual sales for the period forecast and for the corresponding period of the year before.[13]

When we examine the results of our analysis presented in table 8, it appears that the forecasting record of the Dun & Bradstreet survey is decidedly worse than that of the *Fortune* survey, and similar in many respects to that of the shippers' survey. Once more we observe the familiar tendency to overestimate sales in level or falling periods and to underestimate them in rising periods. However,

TABLE 9

Dun & Bradstreet Surveys Included in Sample Used in Table 8

Survey Number[a]	*Date of Survey*	*Reference Points for Expectations*	*Reference Period for Naïve Model*
2	Apr. 1 to Apr. 15, 1948	1948 relative to 1947	First quarter 1948
3	Apr. 15 to May 15, 1949	Second half 1949 relative to second half 1948	First quarter 1949
6	July 20 to July 31, 1949	Second half 1949 relative to second half 1948	May, June, July 1949
8	Sept. 21 to Sept. 30, 1949	Fourth quarter 1949 relative to fourth quarter 1948	Third quarter 1949
10	Nov. 22 to Nov. 30, 1949	First quarter 1950 relative to first quarter 1949	Sept., Oct., Nov. 1949
11	Feb. 9 to Feb. 17, 1950	Second quarter 1950 relative to second quarter 1949	Nov., Dec., Jan. 1949-1950
12	May 1 to May 9, 1950	Third quarter 1950 relative to third quarter 1949	Feb., Mar., Apr. 1950
13	July 6 to July 14, 1950	Fourth quarter 1950 relative to fourth quarter 1949	Second quarter 1950

[a] Reference numbers are our own, since no identifying numbers are provided by the agency conducting the survey.

Source: Compiled from data of Dun & Bradstreet.

[13] Thus the ratio of anticipated to actual sales is obtained for survey 2 by dividing one plus the average expected change by the ratio of 1948 sales to 1947 sales; for survey 3, by dividing one p'us the average expected change by the ratio of sales in the second half of 1949 to sales of the second half of 1948, and so on.

in the present case, both overestimates and underestimates are far more pronounced than those of *Fortune*, especially in the case of durable goods. The average absolute error of forecast, except for retail trade, is large both absolutely and relative to the other surveys (see column 6).

These unfavorable conclusions are fully confirmed by our naïve model tests. As in the case of *Fortune*, the naïve model forecast is an extrapolation of the latest level of sales, seasonally adjusted:

$$A_t^c = A_{t-1} \tag{6}$$

The reference period, t–1, was taken for this purpose as the latest three months immediately preceding the date of the survey; these reference periods are specifically indicated in column 4 of table 9. When the respondents were asked to forecast for a period longer than a quarter, as in surveys 2, 3, and 6, an appropriate multiple, K, of the reference period was used to compute A_t^c. Thus the entries in column 7 of table 8 for Dun & Bradstreet can be rigorously defined by the formula

$$\frac{100}{N}\sum \left| \frac{A_t^c}{A_t} - 1 \right| = \frac{100}{N}\sum \left| \frac{KA_{t-1}}{A_t} - 1 \right| \tag{7}$$

This means that in the case of Dun & Bradstreet we are comparing the average absolute error of forecasts of the respondents with the error that would have been made by extrapolating the latest seasonally adjusted level of sales. We might add that tests were also made for Dun & Bradstreet by employing the same naïve model used to test the shippers' forecast, and the results do not differ significantly from those reported in columns 7 and 8 of table 8.

It is apparent from column 7 that for durable goods the exceptionally large error of the respondents is related in part to the underlying variability of the series forecasted. But the respondents' error is still substantially larger than that of the naïve model. This is also true for nondurable goods and even for retail trade. For the latter industry, however, the record of the Dun & Bradstreet respondents is at least not appreciably poorer than that of the naïve model and is therefore better than the record of the *Fortune* respondents. On the whole, then, the tests of table 8 all concur in indicating that the Dun & Bradstreet record is distinctly inferior to that of *Fortune* and is of the same general quality as the shippers' forecasts.

Before we attempt to interpret this finding we shall discuss briefly the results of our last test of accuracy, based on the correlation between the actual and anticipated rates of change. It will be recalled that when this correlation test was applied to the shippers' anticipations in the interwar period, the results were most disappointing. None of the correlation coefficients was significantly different from zero, and a number of them were actually negative. A similar test could not be applied to the shippers' forecasts in the postwar period because we had no seasonally adjusted data, and it was not possible to analyze each quarter separately because we had only four or five observations for each quarter. No such problem arises, however, for the *Fortune* survey, where we can use seasonally adjusted data. In this case, therefore, we proceeded to correlate directly the average anticipated rate of change with the actual rate of change. The correlation coefficients obtained by this procedure are given in column 9 of table 8.

For every one of the industries analyzed the correlation is now positive; this is certainly a significant improvement over the shippers' forecast in the interwar period. Unfortunately, these correlations are all based on extremely few observations and therefore involve few degrees of freedom—five for retail trade and six for each of the other three industries. When this is taken into account, it is found that in terms of the usual statistical tests, none of these coefficients is significantly different from zero at the 1 per cent level, and only one, that for durable goods, is significant at the 5 per cent level.

Of course, this negative result does *not* imply that there is no relation between actual and anticipated rates of change; it implies only that the number of observations we have so far is too small to permit us to conclude that the observed correlation may not be due to chance. If the respondents' forecasts should maintain the same record of quality in, say, five or six more surveys, the coefficient for the nondurable goods industries and for the private sector of national income would also become significant.

It is doubtful, however, if the same record can be maintained. During the period of observation the forecasts exhibit, as we have seen, a pronounced downward bias; as long as this bias is constant it does not affect the correlation. But if this tendency to underestimate is itself related to the fact that the period covered by the data is dominated by periods of rising activity, then the correlations of table 8 may have a definite upward bias. It is not unlikely, in other words, that if the number of periods of rising and the number of periods of falling activity were more evenly balanced, the record would turn out to be less favorable. This, however, is pure speculation. All we can say for the moment is that the *Fortune* record, as a whole, is at least promising.

The record for Dun & Bradstreet is again impressively worse than that for *Fortune*. For the two manufacturing industries the correlation is practically zero. Only for retail trade does the Dun & Bradstreet record come close to that of *Fortune*, and for this sector this record is poor in both cases.

3. Some possible reasons for differences in the forecasting records of surveys examined

It seems appropriate at this point to venture some guesses as to why the Dun & Bradstreet and shippers' surveys should present rather poor, and in many respects similar, records, in contrast to the superior record of the *Fortune* survey. The shippers' survey differs in procedure from the *Fortune* survey in two major respects:

1. In the shippers' survey the persons interviewed are primarily traffic managers; in the *Fortune* survey they are top executives. From information collected in one of the *Fortune* surveys about the position of the respondents in their respective firms, we know that 46 per cent of them were presidents, 25 per cent vice-presidents, and another 15 per cent were department heads, managers, treasurers, and chairmen of the boards. Obviously, this is a survey of the top brass of the American economy. It is certainly conceivable that traffic managers might be less well acquainted with the plans of the firm and less forward-looking than the *Fortune* respondents.

2. The *Fortune* survey has asked for anticipations for the next half year relative to the current half year, while the shippers' survey asks for anticipations for the next quarter and for actual shipments in the corresponding period of the year before.

In the case of Dun & Bradstreet we have no specific information about the position of the respondents in their firms, though we believe that in this respect this survey comes closer to *Fortune* than to the shippers' survey. However, as indicated earlier, the average size of the responding concerns is smaller for Dun & Bradstreet; and we have some indications, to be discussed presently, that smaller concerns have the poorer forecasting record. Further, the

Dun & Bradstreet survey is definitely much closer to the shippers' survey than to that of *Fortune* in that the respondents are asked for expectations of change in the succeeding period relative to the corresponding period of the year before; and for five of the observations included in our Dun & Bradstreet sample this period is one quarter, just as in the shippers' survey.

While any one of the differences we have mentioned may be responsible for the obvious differences in the quality of the forecasts, we suspect that the most important single factor is the difference in the time-reference for the anticipated change. The validation of this hypothesis will require more intensive analysis than we have been able to carry out so far or to discuss in this paper. However, we should like to present here a few suggestive bits of evidence.

An intensive analysis of the shippers' forecasts from 1928 to date strongly supports the hypothesis that the forecasts are made on the basis of the corresponding quarter of the year before and that this method exerts a profound influence on the nature of the forecasts. As shown more fully in Robert Ferber's "Railroad Shippers' Forecasts," mentioned earlier, these forecasts can be accounted for remarkably well by a simple formula. This formula is similar to the naïve model we have used to test the accuracy of the shippers' forecasts (formula 1), but it differs in one essential respect. Our naïve model forecast can be reduced to the statement that the change for the coming quarter relative to the corresponding quarter of the year before will be equal to the change that has occurred between the current quarter and the corresponding quarter of the year before. The shippers, on the other hand, tend on the average to forecast that the change for the coming quarter relative to the corresponding quarter of the year before will be about 40 per cent of the change that has occurred in the past year. In periods of rising activity such forecasts appear prima facie to be optimistic, since they predict a rise relative to the year before; but in reality they imply that shipments will regress from the latest level toward the lower level which prevailed in the period of reference.[14]

[14] Suppose $A_{t-1}/A_{t-5} = 1.10$ and $E_t/A_{t-4} = 1.04$; then, if the trend is linear, $A_{t-1}/A_{t-4} = 1.10/1.025$ and

$$\frac{E_t}{A_{t-1}} = 1.04 \times \frac{1.025}{1.10} = 0.97$$

Hence

$$\frac{E_t - A_{t-1}}{A_{t-1}} = -0.03$$

In periods of decreasing activity the regressive character of the forecasts operates in the opposite direction. The shippers will tend to forecast a decrease relative to the year before. When adjustment is made for the change that has already occurred in the past year, the forecast will generally imply an actual *increase* over the latest quarter. This means that while prima facie the shippers appear to forecast in the direction of the trend, when adjustment is made for the reference point, they generally turn out to be forecasting against the recent trend. These considerations, incidentally, go a long way toward explaining why, for the shippers' survey, the correlation between the actual and anticipated rates of change turns out to be negative in many instances. The point is that actual shipments are, on the average, more likely to continue the recent trend than to move against it, as the shippers tend to forecast.

When we analyze the Dun & Bradstreet survey and compare its response with that of the *Fortune* survey, much the same phenomenon comes to light. This is brought out rather strikingly in chart 3, which compares what the two surveys report on average change expected in the durable goods industry. The average change expected by Dun & Bradstreet respondents is also shown after adjustment to the base used by *Fortune*.

When we compare the two surveys without any adjustment for differences in the content of the questions asked, we find substantial agreement, at least in the direction of expected change. However, for all but one of the periods for which comparison is possible the adjustment of the Dun & Bradstreet response reverses the direction of the average expected change and destroys the apparent similarity of the responses to the two surveys. From what we know of the history of general business sentiment in the period covered, we are inclined to feel that, by and large, the *Fortune* response and the Dun & Bradstreet unadjusted response give a more accurate picture of expected changes in existing levels of business activity than that given by the Dun & Bradstreet adjusted response. It should be noted, besides, that in every case in which the adjustment reverses the direction of expected change, the actual change was in the direction expected by the *Fortune* respondents.

These facts, though not conclusive, suggest that a major factor responsible for the poorer forecasting record of the Dun & Bradstreet and shippers' surveys, as compared with the *Fortune* survey, is that those surveys ask for change expected relative to the same period of a year ago. Respondents seem to be generally unable to adjust adequately for the amount of change that has already occurred since the previous year. Indeed, from the analysis we have conducted so far, of which chart 3 is only a sample, we think that the unadjusted reply to the Dun & Bradstreet survey is more a

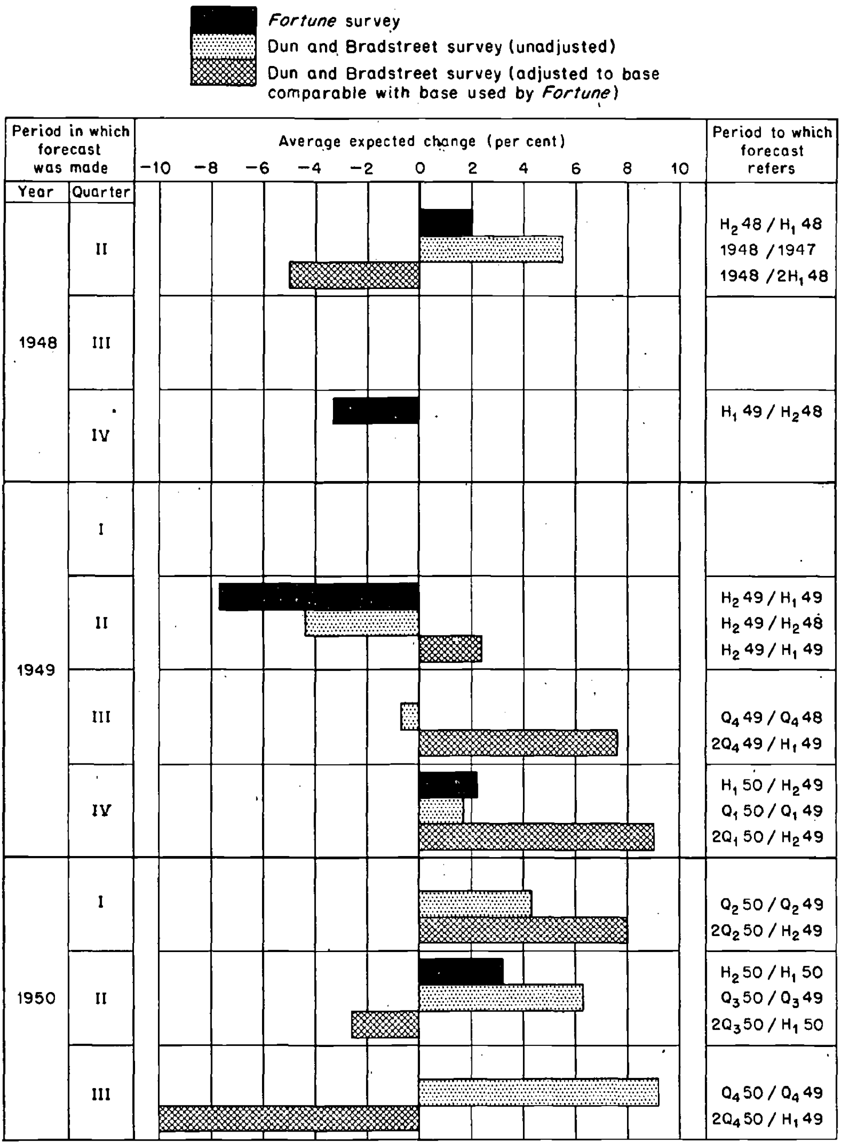

Chart 3. Comparison of Forecasts, Average Expected Changes in Sales, Durable Goods Industry, 1948-1950

measure of change expected relative to an immediately preceding period than of change relative to the same period of a year ago, the specific reference point indicated on the questionnaire. In other words, we think that, on the average, the respondents are not really replying to the question as worded, but are (perhaps subconsciously) answering a question more like the one submitted to the *Fortune* respondents. If this is so, the unadjusted Dun & Bradstreet expected change would be roughly comparable to the *Fortune* response, and the Dun & Bradstreet quarterly surveys that do not overlap the *Fortune* survey might be used to interpolate between the semiannual *Fortune* surveys. This procedure will actually be used in parts of the analysis presented in section D.

4. How well do firms forecast their own sales? A cross-section analysis

In the foregoing discussion we have been concerned exclusively with the question, How well does the average expectation of firms forecast aggregate sales? We have paid no attention to another question which might be raised in connection with an evaluation of expectations, i.e. How well do anticipations of individual firms forecast the firms' own sales? The answers to the two questions could be quite different. To see this point clearly, let us think of the change in the sales of a given firm as consisting of two components: the change in the total sales of the industry and the change in the share of the total accounted for by the given firm. Especially when the change in total sales is not very pronounced, the second component is likely to be the more important for individual firms, although the (weighted) sum of this second component must, of course, be zero for all firms taken together. If, then, firms are able to judge accurately changes in their relative position, this may be enough to produce a fair agreement between forecast and actual changes in their own sales, even if they largely fail in estimating the first component. On the other hand, the average expected change can be a good forecast of the industry's total change in sales only if firms are able to form a good judgment as to the first component. It is, therefore, possible for anticipations of individual firms to provide reasonably good forecasts of the firm's own sales while at the same time the average expectation provides a poor forecast of aggregate sales, and vice versa. Evidence that this possibility is not just a theoretical one was provided by some of our results in connection with the shippers' survey; it will be recalled that individual industries tended to have a better forecasting record than the aggregate of all industries.

For our present analysis we require information on anticipated and actual sales of individual respondents. The shippers' survey cannot be utilized since it gives information on aggregate expectations and aggregate shipments only.[15] In the case of the *Fortune* and Dun & Bradstreet surveys we have anticipations of individual respondents but no matching information on the actual sales of these respondents for the period covered by the forecast.

There is, however, another source of information on anticipations: the survey of anticipated capital expenditures conducted jointly by the Office of Business Economics, Department of Commerce, and the Securities and Exchange Commission. This survey, at least since 1948, has requested the respondents to indicate, early in the first quarter of each year, sales anticipated for that year as well as actual sales for the year before. By matching the returns of the same respondents in successive years, one can secure information on the anticipated and actual sales of a sample of firms. Unfortunately, we have not had direct access to these data because of their confidential character. However, we are able to quote the results of a few tabulations and computations that the Department of Commerce kindly prepared for us.[16]

The first question on which we have some information is that of the correlation between anticipated and actual sales. Selected results are presented in column 4 of table 10 for the years 1948 and 1949.

The coefficients of correlation between actual and anticipated rates of change are in every case positive. While these coefficients are not high, they are nonetheless respectable, considering that we are dealing with cross-section data and with a fairly large number of observations. In fact all but one of them are significant at the 1 per cent level. The exception is the coefficient for the firms of asset sizes 1 and 2, and it is still significant at the 2 per cent level.[17]

[15] Certain Shippers' Advisory Boards have kept records of the actual and expected shipments of individual respondents, but we have been unable to secure this data.

[16] These tabulations were prepared in accordance with an agreement with the Office of Business Economics of the Department of Commerce for a cooperative study of the above survey data. Under this agreement a member of our staff, Jean Bronfenbrenner, joined the Department of Commerce for an eighteen-month period, utilizing funds supplied by our project.

[17] Firms of asset sizes 1 and 2 are the smallest classified and have assets of less than $10 million.

TABLE 10

Anticipated and Actual Changes in Sales of Firms Responding to OBE-SEC Survey of Anticipated Capital Outlays, Manufacturing Industries, 1948-1949

Year for Which Sales Were Forecast (1)	*Asset Size of Firms*[a] (2)	*Number of Observations* (3)	*Correlation between Anticipated and Actual Changes in Sales* (4)	*Average Anticipated Change in Sales*[b] *(per cent)* (5)	*Average Actual Change in Sales*[b] *(per cent)* (6)	*Actual Change in Sales, All Manufacturing Industries (per cent)* (7)
1948	5 and 6	26	0.49	7.8	14.2	
1948	3 and 4	58	0.47	4.4	11.9	
1948	1 and 2	39	0.37	0.5	5.8	
1948	All respondents	123		3.9	10.4	11.9
1949	5 and 6	57	0.45	1.8	—2.1	
1949	3 and 4	208		—4.5	—8.6	
1949	1 and 2	211		—1.9	—7.0	
1949	All respondents	476		—2.6	—7.1	—6.4

[a] Asset sizes 5 and 6 correspond to firms with assets of $50 million or more, 3 and 4 to firms with assets of more than $10 million and less than $50 million, and 1 and 2 to firms with assets of $10 million or less.

[b] Unweighted arithmetic mean.

Source: Compiled from OBE-SEC survey data.

It will also be observed that for 1948 there is a pronounced positive association between the ability of firms to forecast (as measured by the correlation coefficient) and the size of the firms. This relationship, incidentally, might be one of the factors accounting for the better forecasting record of the *Fortune* as against the Dun & Bradstreet respondents.

As we have pointed out, the significant correlations of column 4 might reflect the ability of the firms to forecast their relative position only and not an ability to forecast movements of the entire industry or economy. To what extent this is true can be judged partly by the figures reported in columns 5, 6, and 7 of table 10.

The relationship between the data reported in column 5 and those reported in column 6 suggests that the correlations of column 4 are not completely accounted for by the ability of firms to forecast their relative position. For 1948 respondents on the average anticipated a significant increase in sales, while for 1949 a decrease in sales was expected by all respondents except firms of asset sizes 5 and 6. With this exception the forecast direction of change agrees, in both years, with the actual direction of change.[18] It is also interesting to note that there seems to be a fair relation between the anticipated and actual rates of change as between asset size groups. Thus in 1948 the firms of asset sizes 5 and 6, which made the highest forecast, actually realized the largest increase in sales; while those of sizes 1 and 2, which forecast the smallest increase, also realized the smallest increase. For 1949 the same pattern holds, even though the larger firms missed the direction of change.

The comparison of columns 5 and 6 brings to light once more a phenomenon with which we have grown familiar: respondents, even when they accurately forecast the direction of change, tend

[18] The fact that firms were able to anticipate the broad movements correctly, at least to some extent, suggests that the correlations of column 4 might be due to this ability rather than to the ability to forecast accurately their own individual sales. This hypothesis might be tested by correlating the anticipated change in sales with the "relative" change in sales, that is to say, with the change in sales relative to the industry to which the firm belongs. The firm's change relative to the industry can be approximated by dividing the actual change in sales of the firm by the corresponding change in the total sales of the industry. If the accuracy of the firms' forecasts was due primarily to their ability to forecast the broad changes of the entire industry, rather than their own individual sales, then the correlation of the anticipated change in sales with the relative change should be lower than the correlation shown in column 4. One test of this hypothesis was carried out for the firms of asset sizes 5 and 6 for the year 1949. The correlation, which turns out to be 0.44, is clearly not significantly different from the coefficient of 0.45 shown in column 4 for the same sample.

to underestimate sales when sales are rising, and to overestimate them when they are falling. It will also be noted that, by and large, the average expectation of the respondents to the survey under consideration bears a reasonable resemblance to the anticipations reported by the *Fortune* respondents in the surveys conducted at approximately the same time. Since the OBE-SEC survey is taken in February, it falls midway between the November and May surveys of *Fortune*. If we average the sales expectations of the *Fortune* respondents in the November 1947 and May 1948 surveys, we get, for all manufacturing industries, an average expected increase of 2.7 per cent, compared with an average increase of 3.9 per cent expected by all respondents to the OBE-SEC survey. Similarly, averaging the *Fortune* surveys of November 1948 and May 1949, we get an average anticipated decline of 4.9 per cent, as against an expected decline of 2.6 per cent in the OBE-SEC survey. This comparison is, of course, very rough because of differences in both the time of survey and the specific content of the question on anticipation. Nonetheless, this similarity in reply, as well as the accuracy in forecasting the direction of change, is worth noting, especially when we observe that the anticipation question of the OBE-SEC survey does not involve reference to the corresponding period of the year before, but refers to the entire year.

5. Tentative conclusions

It would be unwise to form any firm conclusions from the analysis presented in the previous pages. Nevertheless we shall summarize briefly the results reached so far and suggest some tentative conclusions.

Of the four surveys analyzed two, the shippers' survey and the Dun & Bradstreet survey, have shown a poor record with regard to direct forecasting ability. In the case of the other two surveys analyzed the forecasting record, even if not brilliant, is certainly not to be passed over lightly. We are not in a position to advance any well-established explanation for these differences. It is not impossible that they might be due only to chance or to the peculiarities of the period of observation. However, our tentative conclusion is that, at least to some extent, the differences result from systematic factors, of which an important one is the way in which the question on anticipation is put. In the two surveys with the poorer record, reference to the corresponding period of the year before seems to impart a regressive character to the respondent's reply, and this influence seems to play havoc with the direct forecasting values of the reply. It is not impossible, however, that with more experience one might learn to adjust for this phenomenon. For instance, we have suggested earlier that in the case of Dun & Bradstreet the unadjusted reply might represent a more accurate measure of the expected change from current levels than would be obtained by assuming that the respondent is actually answering the specific question posed to him.

All our survey data constantly exhibit a bias in underestimating the magnitude of change, especially when change is at all substantial. This tendency to underestimate is one of the major elements contributing to the average error, which was sizable even for the two more successful surveys. Again, with further experience one might well learn to make proper allowance for biases such as this if they are really constant over time. This means that the forecasting value of the anticipations might be considerably enhanced if instead of basing forecasts directly on the response we used some function of the average expected change, which function would make allowance for any systematic bias. Some of the correlation coefficients presented in earlier tables suggest that there may be real possibilities in this direction.

When we first undertook the analysis presented in section C, we had a strong a priori feeling that it would reveal business expectations to be of absolutely no forecasting value. Perhaps this expectation was partly prompted by the fact that the record of economists with regard to unconditional forecasting has been far from brilliant. At this stage of the analysis our a priori conviction is, to say the least, somewhat shaken. It is possible that surveys of expectations might turn out to be a tool of considerable direct forecasting value. Even in this case, however, it is likely that the greatest value of survey information on anticipations will be an indirect one—that of supplying one of the ingredients with which we may hope sometime to turn out better forecasts. It is to this aspect of the problem that we now turn.

D. Can Sales Anticipations Be Used to Forecast Variables Other than Sales?

1. Setting of the problem

Regardless of whether sales (or shipments) anticipations of firms, as ascertained by survey techniques, can be used directly to forecast sales, one might expect that appropriately designed samples of the operating expectations of firms would yield information useful in short-term forecasting of the movements of such variables as production, inventories, and outlays on fixed capital.

At any given point of time the activity of the firm is not entirely directed to the immediate problem of supplying current sales. Production for stocks, and outlays on fixed plant and equipment, are clear instances of activities that are controlled, at least to some extent, by anticipations. Indeed, one might argue that in an economic system of the American type—where production is largely for the market and less for specific orders—anticipations control, at least in the short run, most of the activity of the firm. In other words, not only capital outlays, but production itself, must really depend on sales expected in the future, though possibly only in the very near future.

The above argument, however, does not warrant the conclusion that anticipations and plans are useful for forecasting future production. Current production might well be controlled by current anticipations, but future production will depend on future expectations, and these are, of course, just as unknown at the present time as the future rate of production. Nevertheless, current anticipations and plans might still possess forecasting value, should there be rigidity in expectations and plans.[19] For instance, a firm might plan its production on the basis of a sales forecast made once every quarter and not subject to revision within the quarter. In such a case, information on anticipations and plans as of the beginning of the quarter would enable us to forecast anticipations and plans as of any other point in the quarter.

Rigidity might occur for several reasons. Production and at least some of the other activities indicated above require a certain amount of forward planning and cannot be continuously and immediately adjusted. In many cases the inflow of materials must itself be scheduled and cannot be suddenly stepped up or down. Contracts may have to be made which cannot be canceled easily. Similarly, manpower and productive facilities cannot be secured at a moment's notice.

With regard to those activities not directly keyed to the supplying of immediate sales but based on expectations for rather long periods, as is the case with capital outlays, it is not likely that such

[19] This point has been developed by Franco Modigliani in his paper "Use of Survey Data of Entrepreneurial Anticipations and Plans," presented at the Chicago meeting of the Econometric Society, December 1950.

expectations will be seriously affected by current events, unless such current events are of a rather spectacular character. Further, it is not likely that minor revisions in these expectations would lead to wholesale revisions of plans, except under rather exceptional circumstances.

These considerations lead us to the hypothesis that expectations and plans of firms, when taken in conjunction with other relevant variables, might contribute to the short-run forecasting of certain aspects of the activity of such firms. Clearly, the validity of this hypothesis can be established only by empirical investigation.

As we have argued, the variables most likely to be related to anticipations and plans are production, inventories, and capital outlays. Since the field of capital outlays is being covered in several other papers in this volume, we shall concentrate on the fields of production and inventories. We shall direct our attention primarily to manufacturing industries, since only there can we properly speak of production. However, it is our plan to extend our analysis eventually to every field of economic activity in which inventories, or stocks, play a significant role.

2. Interrelation of Production, Stocks, and Expectations: Some General Considerations and an Analytical Model

The starting point of our analysis is the almost self-evident hypothesis that production in the short run, say over a period of a few months, will depend not only on sales of the firm during the period, but also on initial stocks and the amount of stocks that the firm would find it advisable to hold on the basis of its anticipations for the future. Hence the study of factors controlling the rate of production in the short run involves the study of what we may call the "inventory holding function," i.e. the relationship between the volume of inventories which the firm would want to hold and the information available to the firm. This information would include the firm's anticipations for the future.

We shall start by developing some general considerations as to the factors likely to control the desired level of inventories in manufacturing industries. These considerations will apply primarily to stocks of finished commodities, though they also have some application to stocks of raw materials and goods in process.

We may conveniently distinguish three major sets of factors influencing the desired level of inventories. First, the need of the firm to supply current orders promptly will impose a lower limit to the desired level of inventories. It is this factor that has been most frequently stressed and analyzed; undoubtedly it is one of the most important factors if not *the* most important factor in such industries as wholesale and retail trade.

A second factor, which becomes important when one is concerned with periods of less than a year, is the existence of seasonal fluctuations in sales. This factor is likely to be especially important in the case of manufacturing industries for which sales are characterized by pronounced seasonal fluctuations and for which there are economic advantages in running production at a relatively constant rate throughout the year.

The third important factor is what we may call the "speculative motive." Particularly for those industries in which it is difficult to hedge through the use of organized forward markets, there will be an incentive for firms to increase their stocks when they expect that prices of their inputs and/or outputs will be rising in the future, and to reduce stocks as far as possible when they expect that these prices will be falling.

Since the influence of the last factor does not require further elaboration, and since the significance of the first has already been extensively investigated,[20] we shall devote our analysis particularly to the second.

Clearly, if a function of inventories is that of enabling the firm to produce at a rate more stable than the rate of shipments, then inventories will not bear a constant relation to sales. By and large, we should expect inventories to reach a peak shortly before the heavy shipment season, to decline thereafter until the end of this season, and then to rise again. In other words, the relation between inventories and sales, as measured by the ratio of stocks at the end of a month to sales in the month, will vary considerably throughout the year. Indeed, inventories will tend to trace a cycle roughly inverse to that of shipments, though the exact nature of the relation will depend, of course, on the specific seasonal pattern of shipments. This type of pattern is very clearly illustrated in chart 4. The solid line in this chart shows average monthly shipments of cement for the whole industry, the average being computed for the twenty-one-year period from 1928 to 1949. The broken line shows

[20] An important recent contribution to the subject is to be found in the paper "Optimal Inventory Policy" by Messrs. Arrow, Harris, and Marschak, in *Econometrica*, Vol. 19 (July 1951), pp. 250, 272. This paper also includes a valuable bibliography on the subject.

the average level of stocks at the end of each month during the same period.

Starting from these general observations, we may formulate an analytical model relating shipments to stocks, anticipations, and errors in anticipations.

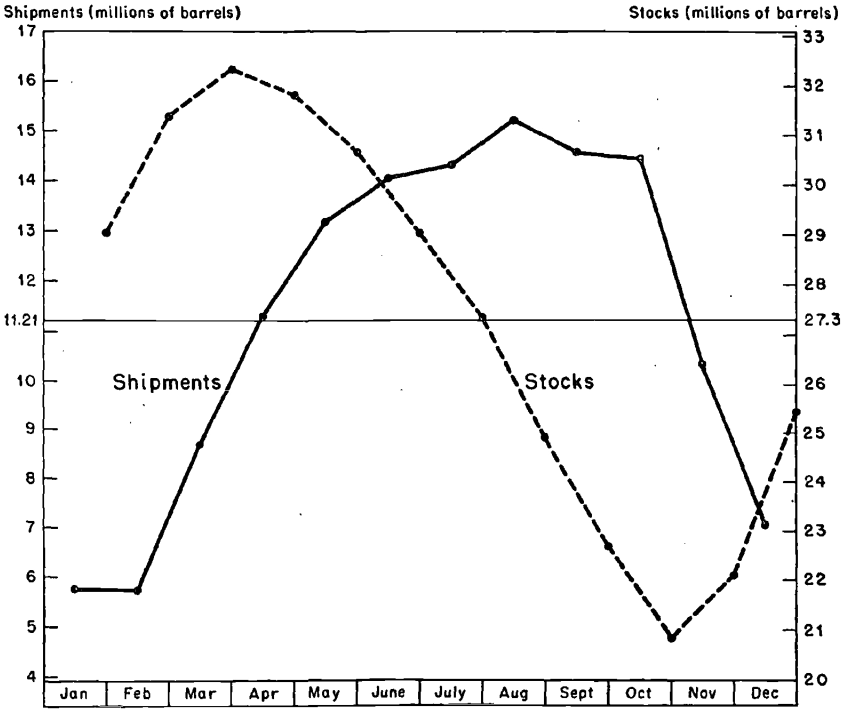

Chart 4. Cement Industry, Average Monthly Shipments and Stocks (End of Month), 1928-1949

We shall define the production year as a fiscal year ending with the close of the last period of heavy shipments. In the case of cement, for instance, the industry considers the close of its shipment year as being at the end of October, though for this particular industry an equally satisfactory year would be one terminating at the end of November. We may conceive of this fiscal year as divided into a number of subperiods, which we shall call seasons. Such seasons are marked off by the points of time at which major production decisions and plans are typically made; the number of seasons may differ from industry to industry, and the seasons need not be of equal length for the same industry. Our purpose is to derive a model which will account for the level of inventories held at the end of each season.

Let z denote the number of seasons in the fiscal year. These seasons will be marked off by z calendar dates, say $t_0, t_1, \ldots, t_i, \ldots, t_{z-1}, t_z = t_0$. The ith season will be defined as the ith period following the date t_0, and will be marked off by dates t_{i-1} and t_i. The level of inventories at any point of time will be denoted by $H(t)$, so that inventories at the end of the ith period will be $H(t_i)$. In general we shall simplify our notation by replacing the symbol t_i by i itself, since this will not create any ambiguity. Thus the symbol for stocks at the end of the ith period, i.e. $H(t_i)$, will be abbreviated to $H(i)$.

We shall need in our model, in addition to stocks, certain flow variables—production and sales. We shall denote respectively by $P(t)$ and $S(t)$ the rate of production and shipments at point t. However, since we are dealing with discrete intervals of time, all we shall need are integrals of these variables over certain intervals. For instance, shipments in the ith season would be

$$\int_{t_{i-1}}^{t_i} S(t)\,dt$$

This integral will be represented by the symbol $S(i;\ i-1)$, the two symbols in parentheses being, respectively, the time subscripts of the upper and lower limits of integration. Similarly $P(i;\ i-1)$ will denote production in the ith season; and $S(z;\ i-1)$ will denote shipments from the beginning of the ith season to the end of the fiscal year; and so on. Finally, we shall need symbols to denote expectations of production, sales, and inventories. For this purpose we shall make use of the symbols which we have just introduced but will append a subscript to denote the point of time at which such anticipations or plans are made. Thus $P_{i-1}(i;\ i-1)$ will denote production for the ith season planned at the beginning of that season; and $S_i(z;\ i)$ will denote sales expectations held at the end of the ith season for the remaining portion of the fiscal year.

We shall assume that for a given industry or, more specifically, for a given firm there is an optimum way of distributing total production over the year. This optimum pattern of distribution will of course depend on the technological and economic characteristics of the firm and industry. At the beginning of any year the total amount that a firm plans to produce during the year will be equal to sales anticipated for the entire year, plus the difference between initial inventories of finished product and the level of such inventories desired for the end of the year, i.e. $P_0(z;\, 0) = S_0(z;\, 0) + H_0(z) - H(0)$. We assume that the optimum production plan involves producing in the ith season a certain fixed proportion γ_i of the entire program (the sum of the γ's is of course unity). Thus the amount of production planned at the beginning of the year for the ith period would be

$$(1) \qquad P_0(i;\, i-1) = \gamma_i\,[S_0(z;\, 0) + H_0(z) - H(0)]$$

If the seasons are all of equal length, and the optimum plan involves distributing production evenly over the year, then $\gamma_i = \gamma_j = 1/z$. In general, however, there is no reason to believe that this equality will hold, even if the seasons are of equal length. To begin with, there may be technological factors that make it impossible to run production at the same rate through the year; e.g. certain types of productive facilities may have to be overhauled at regular intervals. Further, climatic conditions might make it more economical to concentrate production in certain seasons of the year, as when one of the inputs is a perishable crop. Again, an absolutely constant rate of production might force the firm to secure an uneconomical amount of costly storage facilities. As a result of these and other factors the most economical plan might involve different rates of production for the different seasons, even if the firm knew with certainty the total amount it would have to produce during the year (as, for instance, if the total output had been sold forward).[21]

In addition we must take into account the risk factor arising from uncertainty. Uncertainty as to the total amount that will be sold during the year will tend to be greatest at the beginning of the year and to decrease as the year progresses and as the heavy season approaches. This factor should induce the firm to postpone production and should therefore operate in the direction of a plan in which the rate of production in the early season is less than the average over the year or, at any rate, less than what would be desirable in a world of perfect certainty. But uncertainty is sure to work in this direction only if the cost of production is approximately independent of the rate of production, as is the case when marginal costs are constant. With a nonlinear cost function, on the other hand, it can

[21] See Herbert Solow, "Operations Research," *Fortune*, April 1951; also Philip M. Morse and George E. Kimball, *Methods of Operations Research*, 1st edn., rev. (Wiley & Sons, 1951).

be shown that uncertainty may well push in the opposite direction. We shall not enter into any further theoretical analysis of these questions.[22] The foregoing discussion is sufficient to establish that there is no a priori reason to assume that all the γ's will be equal.

Now, it follows from our hypothesis, and from equation 1, that the share of the total program which, as of point zero, is planned to be produced from the beginning of the ith season to the end of the year will be given by

$$(2) \qquad P_0(z; i-1) = [S_0(z; 0) + H_0(z) - H(0)] \sum_{j=i}^{z} \gamma_j$$

Further, the proportion of this share programmed for the ith season itself will be

$$(3) \qquad \frac{P_0(i; i-1)}{P_0(z; i-1)} = \frac{\gamma_i[S_0(z; 0) + H_0(z) - H(0)]}{\sum_{j=i}^{z}\gamma_j[S_0(z; 0) + H_0(z) - H(0)]} = \frac{\gamma_i}{\sum_{j=i}^{z}\gamma_j} \equiv \Gamma_i$$

Let us now consider the situation that will exist at the beginning of the ith season. The shipments expected by the firm at this time for the balance of the year will be $S_{i-1}(z; i-1)$, and the production program for the balance of the year will be

$$(4) \qquad P_{i-1}(z; i-1) = S_{i-1}(z; i-1) + H_{i-1}(z) - H(i-1)$$

What will be the optimum way of distributing this production over the remaining seasons, i to z? We shall make the assumption that at every point of time an equation analogous to 4 holds, i.e. that

$$(5) \qquad \frac{P_{i-1}(i; i-1)}{P_{i-1}(z; i-1)} = \Gamma_i$$

or

$$\begin{aligned} P_{i-1}(i; i-1) &= \Gamma_i P_{i-1}(z; i-1) \\ &= \Gamma_i[S_{i-1}(z; i-1) + H_{i-1}(z) - H(i-1)] \end{aligned}$$

where Γ_i is defined by equation 3. It should be noted that equation 5 cannot be derived from 3; it represents an independent assumption which we feel to be reasonable, at least as a first approximation. Equation 5 embodies the first of our basic assumptions as to the short-run determinants of production plans.[23]

[22] An analysis of these and related problems, with special emphasis on the effect of uncertainty, will be given in forthcoming publications of our project and especially in the summary volume mentioned earlier.

[23] For this assumption to be tenable, it is necessary that the length of the (technological) production period be small relative to the length of the "season." If this condition is not satisfied, equation 5 and much of the discussion

Our next problem is that of determining the relation between production plans made at the beginning of the given season and actual production in the course of the season, i.e. in our notation, the relation between P_{i-1} $(i; i-1)$ and $P(i; i-1)$. This relation must depend on two major factors: (1) the extent to which the expectations of the firm change in the course of the season itself, and (2) the extent to which the firm finds it advantageous to adjust its production in the course of the season so as to conform with its revised expectations.

Suppose, first, that expectations are revised continuously and production plans are adjusted instantaneously to conform with the revised expectations. In this case actual production for the ith season would depend on the path traced by expectations from the beginning to the end of this season. For the purpose of this discussion expectations as of any point of time within the ith season can best be thought of as representing the total amount the firm expects it will have to produce from the beginning of the ith season to the end of the year. At the beginning of the season, as we have already seen, this amount is

$$(6) \qquad S_{i-1}(z; i-1) + H_{i-1}(z) - H(i-1)$$

while by the end of the season it will be

$$(7) \qquad S_i(z; i) + S(i; i-1) + H_i(z) - H(i-1)$$

Thus the time series describing the requirements anticipated at successive points of time within the ith season begins at a level given by 6 above and ends at a level given by 7. Suppose that between these two points the path is approximately monotonic (i.e. continuously rising or continuously falling); then it may be shown that actual production must fall somewhere between the quantity that would have resulted if anticipated requirements had been held unchanged throughout the season at the level given by 6 and the quantity that would have resulted if they had been held unchanged

of the present and following two sections must be modified to take into account the effect on production of goods in process at the beginning of the ith season. Clearly, if the production period were as long as or longer than one season, then the output within the season would be determined entirely by previous "starts," assuming that it is not economical to discontinue production already in process. No attempt will be made in this paper to develop systematically the required modifications, since for those industries for which empirical tests of our model are presented the condition mentioned at the beginning of this footnote is likely to be approximately fulfilled. However, some indications of how our model can be generalized are given in footnote 24.

at the level given by 7. In other words, the level of production can be described by the equation

$$(8)\quad P(i; i-1) = (1-m_i)\Gamma_i[S_{i-1}(z; i-1) + H_{i-1}(z) - H(i-1)] + m_i\Gamma_i[S_i(z; i) + S(i; i-1) + H_i(z) - H(i-1)]$$

where the coefficient m_i must have a value between zero and one, as long as the path traced by expectations is monotonic. In the special case in which the path of expectations is linear it can be shown that m_i is a monotonic increasing function of Γ_i and that its value will be close to one-half if Γ_i is small and will approach unity as Γ_i approaches unity (toward the end of the year).

In general there is, of course, no reason to suppose that the path of expectations for a single firm, or even for an aggregate of firms, should be linear within any given season. However, if our data are time series of several years, then it is not unreasonable to assume that the average path might be described approximately by a straight line. Accordingly, the average value of m_i taken over a number of years may be expected to increase for successive seasons of the year from a lower value close to one-half to an upper value close to unity.

Equation 8 was derived under the assumption that the firm would find it profitable to change its production plan continuously to conform with its revised expectations. If, on the other hand, production plans are completely rigid within the season, then production will continue at the level planned at the beginning of the season, that is:

$$(9)\quad P(i; i-1) = P_{i-1}(i; i-1) = \Gamma_i[S_{i-1}(z; i-1) + H_{i-1}(z) - H(i-1)]$$

It seems reasonable to assume that plans are neither perfectly rigid nor perfectly adjusted. We might therefore expect production to fall between the value of the right-hand side of equation 8 and the value of the right-hand side of equation 9; that is, production might be expressed as a weighted average of production under the assumption of perfect adjustability and production under the assumption of perfect rigidity, with weights a and $(1-a)$ respectively. The coefficient a will have a value between zero and one and will be smaller the greater the rigidity of the plan:

$$\begin{aligned}(10)\quad P(i; i-1) &= (1-a_i)\Gamma_i[S_{i-1}(z; i-1) + H_{i-1}(z) - H(i-1)] \\ &+ a_i\Gamma_i\{m_i[S_i(z; i) + S(i; i-1) + H_i(z) - H(i-1)] \\ &+ (1-m_i)[S_{i-1}(z; i-1) + H_{i-1}(z) - H(i-1)]\} \\ &= \Gamma_i(1-a_im_i)[S_{i-1}(z; i-1) + H_{i-1}(z)] \\ &+ \Gamma_ia_im_i[S_i(z; i) + H_i(z)] + \Gamma_ia_im_iS(i; i-1) \\ &- \Gamma_iH(i-1)\end{aligned}$$

The coefficient *am* measures the extent to which new information, represented by the actual level of sales and revised expectations during the season, influences production for that season. Borrowing a concept from the field of servomechanisms we may label it the "feed-in" coefficient. If plans and expectations are perfectly rigid within the season so that no new information can be fed in, then a, and therefore *am*, will be zero, and production will be equal to the initial plan. If, on the other hand, production (and expectations) can be adjusted immediately to conform with the latest available information, then a will be unity and the coefficient *am* reduces to the coefficient m, whose properties we have already discussed.[24]

In equation 10 the dependent variable is production. This equation, however, can be used to express the relation between end inventories and the variables appearing on its right-hand side. This

[24] We may briefly indicate at this point how the results expressed by equation 10 might be generalized to include the case (mentioned in footnote 23) where the length of the production period is not small relative to the length of the season (but is still shorter than one full season). Let θ denote the production period, i.e. the time required by the given technology of production, for an item to run through the entire production process, and let $i' = i - \theta$. Let $R(t)$ denote the rate of "starts" at time t. We must then have

$$P(i; i-1) = R(i'; i'-1)$$

In order to account for the quantity $R(i'; i'-1)$ we may, in analogy to equation 5, assume

$$R_{t'-1}(i'; i'-1) = \Gamma_{t'}\{S_{t'-1}(z; i'-1) + H_{t'-1}(z) - [H(i'-1) + P(i-1; i'-1)]\}$$

The quantity in braces represents total anticipated requirements, in terms of starts, as of point $i'-1$ (anticipated sales and desired end inventories less initial stocks and production already in course); it corresponds to equation 6. Similarly, equation 7 would be replaced by

$$S_{t'}(z; i') + H_{t'}(z) + S(i'; i'-1) - [H(i'-1) + P(i-1; i'-1)]$$

Introducing assumptions analogous to those leading to equations 8 and 10 and taking into account the identity

$$H(i'-1) + P(i-1; i'-1) = H(i-1) + S(i-1; i'-1)$$

we end up with

$$(10a)\quad P(i; i-1) = R(i'; i'-1) = \Gamma_{t'}(1-a; m)[S_{t'-1}(z; i'-1) + H_{t'-1}(z)] + {}_{t'}a_t m_t[S_{t'}(z; i') + H_{t'}(2)] + \Gamma_{t'}a; m_t\, S(i'; i'-1) - \Gamma_{t'}H(i-1) - \Gamma_{t'}S(i-1; i'-1)$$

The right-hand side of this equation differs from that of 10 by the fact that sales expectations and actual sales relate to points or intervals of time leading the season by an amount θ, and by the presence of one extra term, the last. In the limiting case where $\theta =$ zero so that $i' = i$, this last term becomes zero and 10a coincides with 10. If direct information on "starts" were available, our equations could easily be modified to take this additional information into account; some difficulties would arise, however, if the firm were to vary significantly the length of the production period. In 10a this possibility is formally accounted for through the coefficient a_t.

can be done by utilizing the fundamental identity relating sales, production, and stocks of finished product, namely:

$$(11) \qquad H(i) \equiv H(i-1) + P(i; i-1) - S(i-1)$$

Substituting 10 into 11 we derive

$$(12) \qquad \begin{aligned} H(i) = {} & \Gamma_i[S_{i-1}(z; i-1) + H_{i-1}(z)] \\ & + (1-\Gamma_i)H(i-1) + a_i m_i \Gamma_i[S_i(z; i) + H_i(z) \\ & - S_{i-1}(z; i-1) - H_{i-1}(z)] \\ & - (1-a_i m_i \Gamma_i)S(i; i-1) \end{aligned}$$

Equations 10 and 12 represent the basic hypothesis that underlies the several statistical analyses which we have carried out.

3. Generalizations of the model and implications

Before we describe the tests and the results obtained, it will be necessary to set out a few more considerations in connection with our hypothesis.

1. Equations 10-12 were derived from a model which assumes that the only function of inventories is to permit the firm to operate at a fairly uniform rate even though its shipments are subject to seasonal fluctuations. This assumption, incidentally, is of some importance in justifying one feature of our model that might seem unrealistic, namely, that the anticipations entering our equation are always for the balance of the year and do not go beyond the year itself. The rationale for this aspect of our model need not be discussed here since it is developed in a joint paper by the senior author and Franz E. Hohn in a forthcoming issue of *Econometrica*. It is shown there that, under the stated assumption as to the role of inventories, for seasonal industries the optimum production plan for one year is generally independent of expectations for later years, especially if there are substantial costs in storing the output. As a matter of fact it is well known that plans of firms relating to current operations are frequently set up for the fiscal year and do not extend beyond, except for the lead time needed to procure certain raw materials and parts.

No doubt, to assume that the only function of inventories is to smooth production operations is unduly restrictive. The need to carry enough stock to assure continuity of operations must play a role, at the very least for goods in process. Recognition of this function of inventories, however, does not seem to require any significant modification in the variables entering equation 10, though the coefficients of these variables might be somewhat altered.

2. The influence of cost and price expectations can be handled easily by adding certain variables to equation 10. The same set of considerations underlying this equation leads us to the conclusion that the additional variables should be primarily cost expectations both as of the beginning and as of the end of the season.

3. In equation 10 we have implicitly assumed that the production plan made at point i depends exclusively on information at point i itself, and is therefore independent of earlier events, and in particular of plans that were made for the ith season at the beginning of the year or at some later intermediate points. Clearly this is somewhat unrealistic, but we must forgo a thorough discussion of this point in this paper. It will suffice to say that a more general form of equation 10 might have to include variables with dates earlier than point of time i, and these variables may be both anticipated and realized variables. This principle will find application in some of the tests described below.

4. A problem closely related to the one just discussed is the influence of limitations of productive capacity on our hypothesis 10. It is related to the previous subject because the level of capacity in existence is obviously tied up with expectations held for the given point of time at earlier points of time. It is clear that the production plan, or actual production, cannot exceed existing capacity. It follows that whenever the expression on the right-hand side of equation 5, 8, or 10 takes a value greater than productive capacity for the ith season, then the equation no longer holds, and it should take a different form; in particular, equation 10 should take the form

$$P(i; i-1) = P^c(i; i-1) \tag{13}$$

Here P^c $(i; i-1)$ denotes the maximum amount that can be produced in the ith season with existing capacity. It is well to remember, however, that in many cases the notion of capacity is not merely a physical or engineering one, but rather an economic one. The point is that, beyond a certain critical point, cost will tend to rise rapidly even before an absolute ceiling is reached, if there be such a ceiling. If we interpret P^c to denote this critical level, and if we denote the value of the right-hand side of equation 10 by P^*, then we might expect that whenever P^* exceeds P^c, actual production will be less than P^* though it will tend to exceed P^c itself. It is in fact not unreasonable to expect that actual production P will tend to exceed P^c by an amount that depends on the extent to which P^* exceeds P^c. In other words, we may expect an equation of the following type to hold:

$$P - P^c = f(P^* - P^c)$$

that is,

$$P = P^c + f(P^* - P^c) \tag{14}$$

where f denotes some monotonically increasing function.

Equations 10 and 14 can be subsumed under a single more general form if we make use of the notion of a "switching device" that has been made familiar to economists by some recent writings.[25]

This more general equation states that $P(i; i-1)$ will be equal to the right-hand side of 10 or the right-hand side of 14 depending on whether the right-hand side of 10 is smaller or larger than P^c. These conditions may be stated by means of the equation

$$\begin{aligned} P(i; i-1) &= P^*(i; i-1) + d[P^c + f(P^* - P^c) - P^*] \\ &= d[P^c + f(P^* - P^c)] + (1-d)P^* \end{aligned} \tag{15}$$

Here the switching coefficient d is defined as having the property

$$d = \begin{cases} 1 \text{ if } P^*(i; i-1) \geq P^c(i; i-1) \\ 0 \text{ if } P^*(i; i-1) < P^c(i; i-1) \end{cases}$$

5. We should like to make one more general comment as to the significance of the empirical tests of the hypothesis that we are about to present. Equation 10 (or its generalizations just considered) tells us that production in the ith season should depend on two types of variables: certain conventional or *ex post* variables such as initial stocks, sales, and productive capacity; and variables measuring anticipations of the firm. The latter is of course a type of variable that has seldom, if ever, been used before in empirical analysis, and a good deal of interest must center on whether we can actually detect the influence of these "psychological" variables. In particular, it should be noted that in our equation the symbol S_{i-1} denotes "operating expectations," or the expectations that really underlie the plan of the firm.

There is no a priori way of telling whether the information on expectations that has been gathered in the past through the types of

[25] Such switching devices, for instance, play an important role in J. R. Hicks' business cycle model, though they are not called by this name. See his *A Contribution to the Theory of the Trade Cycle* (Oxford: Clarendon Press, 1950).

surveys at our disposal really reflects operating expectations. One may easily think of many reasons why it may not do so. For example: the personal views of the respondent may not coincide with the expectations underlying the plan, which presumably must reflect some kind of consensus of top executives; the respondent may be reporting his present momentary feelings, which do not coincide with operating expectations, though he might have originally concurred with these expectations; and he may not be well informed as to the operating expectations of the firm.

In testing the influence of the expectation variables at our disposal on production (or stocks), we have, therefore, a double interest: to know whether these variables will be useful in forecasting and to test whether there is any evidence that production responds to our psychological variables. The latter question is important, first, because many economists have been inclined to discount heavily the influence of such psychological variables; and second, because if we can establish the relevance of these variables in controlling production, this will serve also to confirm that our expectation variables do measure operating expectations, at least to some extent.

There is a real difference between the question whether expectations are "relevant" in explaining the behavior of production and the question whether they are useful for forecasting. This difference can be seen from the considerations discussed below.

Our basis equation (10) involves two expectation variables, of which one, initial expectations, S_{t-1}, leads the production variable whose behavior we are trying to explain, while the other, end expectations, S_t, lags it. Furthermore, we see that the relative influence of these variables on production, as measured by their coefficients, depends on the size of the feed-in coefficient $a_t m_t$. If the feed-in coefficient is close to zero, then initial expectations will play a dominant role, and the influence of end expectations will be small; while if the feed-in coefficient is close to unity, the very opposite will be true. From the point of view of the *significance* of expectations the size of the feed-in coefficient is of little consequence. For if our hypothesis is basically correct and our measures of expectation satisfactory, then, regardless of the size of the feed-in coefficient, our statistical tests should show that at least one of the expectation variables exerts a significant influence on production (or inventories); and if this much can be established, it would be sufficient to support the hypothesis that expectations are *relevant*.

On the other hand, the size of the feed-in coefficient is most important from the forecasting point of view. If this coefficient is high, then, at best, we might be able to exhibit the influence of *end* expectations; but this result would be of little help in forecasting, for in order to exploit this fact it would be necessary to forecast end expectations themselves (as well as sales). For expectations to be most useful in forecasting, *initial* expectations, which lead production, should play the significant role; if this is to be so it is necessary both that expectations be relevant and that the *feed-in coefficient be not too large.*

One should not, however, jump to the conclusion that initial expectations can be useful in forecasting only if the feed-in coefficient is small; in reality their usefulness will depend also on the accuracy with which firms are able to forecast the future. This point is best seen if we rewrite equation 10 in the form

$$
\begin{aligned}
(16) \qquad P(i;i-1) = {} & \Gamma_i[S_{i-1}(z;i-1) + H_{i-1}(z)] \\
& + a_i m_i \Gamma_i\{[S_i(z;i) + S(i;i-1) + H_i(z)] \\
& - [S_{i-1}(z;i-1) + H_{i-1}(z)]\} - \Gamma_i H(i-1)
\end{aligned}
$$

If we examine the expression inside the braces on the right-hand side of the above equation, it will be seen that it represents essentially the difference between required production from the beginning of the *i*th season to the end of the year as anticipated at the beginning of the *i*th season and that production as anticipated at the end of the *i*th season. This means that if we forecast production using initial expectations and stocks alone, we shall commit an error that is equal to the difference in these expectations, times the feed-in coefficient (and multiplied again by the optimum share of this program assigned to the *i*th season). Now this difference clearly depends on how well firms can forecast in the short run; if they are able to forecast with great accuracy, then the difference will be zero, and our forecast from stocks and initial expectations will be satisfactory regardless of the size of the feed-in coefficient. Thus the usefulness of initial expectations and stocks for forecasting production depends really on the product of two factors, the size of the feed-in coefficient and the ability of firms to forecast.[26]

The foregoing discussion leads to a second set of considerations. Clearly, the size of both of the factors just mentioned will depend on the length of the season *i*. The shorter the season, the smaller

[26] It is not even strictly necessary that the forecasts be accurate. It is sufficient that anticipated requirements as of the beginning of the season be highly correlated with anticipated requirements as of the end of the season.

the error of the firms' forecast will tend to be, and the same is likely to hold for the feed-in coefficient, since it is true at least for the factor m. On the other hand, the usefulness of the forecast will decrease with the shortness of the season, and for very short seasons a simple extrapolation of level may be just as satisfactory on the average. So even if we find we can make good short-term forecasts by using exclusively the lagged terms of equation 10, we should make sure that such forecasts are better on the average than those that might be made by some obvious naïve model.

The size of the feed-in coefficient am may also be expected to vary from season to season. We have already seen that the factor m should tend to grow as the end of the fiscal year approaches. A similar tendency may also exist for the factor a. This factor, it will be recalled, measures the extent to which plans are revised within a season to conform with revised expectations. Now there will typically be a sizable cushion of inventories in the early seasons and plenty of opportunity to correct errors in later seasons. Both of these factors should tend to reduce the pressure to adjust plans quickly. However, toward the end of the year, failure to adjust plans may result in actual loss of sales, unless the "normal" level of inventories planned for the end of the year is a large fraction of sales in the last season.

We therefore have some reason to expect, on a priori grounds, that the size of the feed-in coefficient, and hence the forecasting value of initial expectations, should be greatest toward the beginning of the fiscal year.

We may point out, finally, that if the feed-in coefficient is large and expectations are relevant, then in order to make good forecasts it becomes necessary to forecast, at the beginning of the period to be forecast, the end expectations of the firm. This task involves, in turn, a study of the factors controlling the formation and change of economic expectations. While a good deal of work has been done on this subject in the course of our project, we shall not be able to touch on this here.

4. Adaptations of the Model to Available Data

In order to test equation 10 or any of its generalizations, we should have information, for each season of the year, on production, stocks, sales, initial anticipations for the balance of the year, and end anticipations for the balance of the year. Information of this type is rather scanty, even if we are willing to define our season arbitrarily so as to fit available data. Accordingly, in every one of the tests described below we have had to modify the model somewhat to make it fit the type of information available. Most of these elaborations of the model are best described in connection with each specific test. However, there is one modification that is common to all tests and we may therefore conveniently discuss it here.

None of our sources of expectations data supplies us with expectations for the balance of the fiscal year. In every case they refer rather to certain calendar periods which are, with few exceptions, either calendar quarters or calendar half years. Suppose, for instance, the information refers to quarters; then using our notation and identifying the quarter with our season, we might at best know the variables $S_{i-1}(i; i-1)$ and $S_i(i+1; i)$ instead of the variables $S_{i-1}(z; i-1)$ and $S_i(z; i)$, which actually enter our equation 10. In order to get over this difficulty we have to introduce an assumption that seems to us a reasonable approximation—that, by and large, firms usually expect their sales to exhibit the normal seasonal pattern. Thus if s_i denotes the normal seasonal coefficient for the ith season, i.e. the proportion of the yearly sales normally occurring in the ith season, we assume that

$$(17) \qquad S_0(i; i-1) = s_i S_0(z; 0) \qquad i = 1, 2, \ldots, z$$

where

$$\sum_{i=1}^{z} s_i = 1$$

The above assumption enables us to express $S_0(z; i-1)$ in terms of $S_0(i; i-1)$ since

$$(18a) \qquad \begin{aligned} S_0(z; i-1) &= \sum_{j=i}^{z} s_j S_0(z; 0) \\ &\doteq \sum_{j=i}^{z} s_j \frac{S_0(i; i-1)}{s_i} \qquad \text{(from 17)} \\ &= \sigma_i S_0(i; i-1) \end{aligned}$$

where

$$(18b) \qquad \sigma_i = \frac{\sum_{j=i}^{z} s_j}{s_i}$$

Our problem, however, is to express $S_{i-1}(z; i-1)$ in terms of $S_{i-1}(i; i-1)$. To do so, we have to introduce the further assumption that the relation between $S_{i-1}(z; i-1)$ and $S_{i-1}(i; i-1)$ is the same as the relation between $S_0(z; i-1)$ and $S_0(i; i-1)$, that is:

$$(19) \qquad S_{i-1}(z; i-1) = \sigma_i S_{i-1}(i; i-1)$$

This equation in effect states that at *any* point of time sales anticipated for the remaining portion of the year bear the normal seasonal relation to sales anticipated for the immediately following season.

By means of equation 19 we are now in a position to transform the variables relating to expected sales on the right-hand side of equation 10 to the form in which these variables are expressed in the data available to us. This transformation is accomplished by replacing $S_{i-1}(z; i-1)$ and $S_i(z; i)$ by $\sigma_i S_{i-1}(i; i-1)$ and $\sigma_{i+1} S_i(i+1; i)$ respectively.

After this substitution, equation 10 will contain only one variable about which we do not usually have any direct information, namely $H_i(z)$, planned end inventories.

Since the end of the fiscal year, as defined by us, is followed by a period of seasonally low sales, it follows that if the only function of inventories were the smoothing of production operations, we should expect the firm to plan to hold zero inventories at the year end.[27] If, however, we take into account the other function traditionally assigned to inventories, that of providing a reserve against error in sales expectations, then it seems reasonable to assume that planned end stocks should be roughly proportioned to sales expected in the last season of the year, that is:

$$(20) \qquad H_i(z) = \beta S_i(z; z-1) = \beta s_z \frac{S_i(i+1; i)}{s_{i+1}} = \beta_{i+1} S_i(i+1; i)$$

where

$$\beta_{i+1} = \beta \frac{s_z}{s_{i+1}}$$ [28]

[27] On this point see section D 3, point 1.

[28] If the seasons were short (which is approximately equivalent to saying that z is large), then the assumption expressed as equation 20 might not be entirely satisfactory for values of i close to z. If the firm happened to be seriously overstocked at this point of the year (in the sense defined by equation 24, our assumption might involve a violent contraction in production and, under extreme conditions, even negative production, which is of course impossible. This difficulty could be handled by specifying that under certain stated conditions $H_i(z)$ would not be equal to the right-hand side of equation 20, but would depend instead on sales expectations for the entire following fiscal year. It does not, however, seem worth while to complicate our model in this fashion, since in our statistical tests the seasons are defined as periods of three months, and for periods of this length equation 20 may be expected to represent a reasonable approximation.

By means of equations 19 and 20 we may now reduce equations 10 and 12, respectively, to the following forms, in which no variable appears except those about which we usually have information:

$$(21a) \qquad P(i; i-1) = \Gamma_i(1-a_i m_i)(\sigma_i + \beta_i)S_{i-1}(i; i-1) + \Gamma_i a_i m_i(\sigma_{i+1} + \beta_{i+1})S_i(i+1; i) + \Gamma_i a_i m_i S(i; i-1) - \Gamma_i H(i-1)$$

$$(21b) \qquad H(i) = \Gamma_i(1-a_i m_i)(\sigma_i + \beta_i)S_{i-1}(i; i-1) + \Gamma_i a_i m_i(\sigma_{i+1} + \beta_{i+1})S_i(i+1; i) - (1-\Gamma_i a_i m_i)S(i; i-1) + (1-\Gamma_i)H(i-1)$$

These two equations represent the basic model tested in the time-series test in section D 6 below.[29]

It will be noted that the coefficients of each of the independent variables appearing in these equations are characterized by subscripts identifying them with the particular season i, to which the equation refers. In other words, these coefficients may generally be expected to assume different values in the different seasons of the year. Furthermore, our model enables us to draw some interesting tentative conclusions as to the way in which these coefficients may be expected to change as the year progresses.

First, concerning the role of initial stocks, it is seen that the coefficient of this variable in equation 21b is $-\Gamma_i$, and this parameter, as can be verified from its definition, equation 3, will tend to increase from a small fraction toward unity as we approach the end of the fiscal year. Hence initial inventories should play a growing role in explaining production decisions, while at the same time they should play a decreasing role in explaining the behavior of end inventories (see equation 21b).

Similarly, because of the behavior of Γ_i and because the feed-in coefficient itself is likely to grow larger, the role of actual sales

[29] Strictly speaking, equations 21a and 21b hold for values of i different from z. When i takes the value z, end expectations cease to have any meaning. In this case, taking into account the fact that $\Gamma_z = \sigma_z = 1$, these formulas should be amended as follows:

$$P(z; z-1) = (1-a_z m_z)(1+\beta)S_{z-1}(z; z-1) + a_z m_z(1+\beta)S(z; z-1) - H(z-1)$$

$$H(z) = (1-a_z m_z)(1+\beta)S_{z-1}(z; z-1) - (1-a_z m_z-\beta a_z m_z)S(z; z-1) \doteq (1-a_z m_z-\beta a_z m_z)[S_{z-1}(z; z-1) - S(z; z-1)] + \beta S_{z-1}(z; z-1)$$

within the period will also grow in importance as the year progresses. On the other hand, from definition 18b we see that σ_i must necessarily fall as we move toward the end of the year. It follows that both expectation variables will tend to decrease in importance relative to actual sales,[30] and this tendency will be even further accentuated in the case of initial anticipations if the feed-in coefficient tends to increase.

The model we have just developed also enables us to give an operational definition of the notion of "normal" or "equilibrium" stocks at point i, $H^e(i)$, which notion plays a role in the tests of section D 5.

To begin with, it seems reasonable to say that stocks at the beginning of the year are normal in relation to expectations held then, if the firm is planning neither to add to these stocks nor to decrease them in the course of the year as a whole; hence normal stocks at the beginning of the year, $H^e(0)$, will be defined by the equation

$$H^e(0) = H_0(z) = \beta s_z S_0(z; 0)$$

Now if beginning stocks are normal according to this definition, i.e. if $H(0) = H^e(0) = H_0(z)$, then it may be shown that our model implies that the level of stocks planned for any other season, $H_0(i)$, will be given by

$$(22) \qquad H_0(i) = K_i S_0(z; 0) = K_i \frac{S_0(z; i)}{\sum_{j=i+1}^{z} s_j} = K_i \frac{S_0(i+1; i)}{s_{i+1}}$$

where

$$(23) \qquad K_i = \beta s_z + \sum_{j=1}^{i} (\gamma_j - s_j)$$

Thus if initial stocks are normal, then stocks planned for the end of the ith season will be proportional to sales anticipated for the balance of the year, $S_0(z; i)$, as well as to sales anticipated for the immediately following season, $S_0(i + 1; i)$, the proportionality factors being, respectively

$$\frac{K_i}{\sum_{j=i+1}^{z} s_j} \text{ and } \frac{K_i}{s_{i+1}}$$

We will now say that stocks at the end of the ith season are normal if they bear the above mentioned ratio to sales expected at that

[30] It may be noted in particular that in our model the coefficient of end expectations may be regarded as zero in the last season since these expectations do not appear in the equation (see footnote 28).

point of time. In other words, the normal level of stocks for the end of the ith season will be defined thus:

$$(24) \qquad H^e(i) = \frac{K_i}{\sum_{j=i+1}^{z} s_j} S_i(z; i) = \frac{K_i}{s_{i+1}} S_i(i+1; i)$$

The quantity $H(i) - H^e(i)$ can then be regarded as a measure of imbalance in inventories as of the end of the ith season. It can be shown that, by means of these definitions, equation 5 can be transformed to the following useful form:

$$\frac{P_{i-1}(i; i-1)}{\gamma_i} = \frac{S_{i-1}(i; i-1)}{s_i} + \frac{1}{\sum_{j=1}^{i} \gamma_j} [H^e(i-1) - H(i-1)]$$

It follows from our definition of the coefficients γ_i and s_i that the quantities

$$\frac{P_{i-1}(i; i-1)}{\gamma_i} \text{ and } \frac{S_{i-1}(i; i-1)}{s_i}$$

represent, respectively, planned production and anticipated sales for the ith season at *seasonally adjusted annual rates.*

The above equation can therefore be given the following simple interpretation: if stocks are below (above) normal so that the quantity $H^e(i-1) - H(i-1)$ is positive (negative), then production, seasonally adjusted, will be planned to exceed (fall short of) seasonally adjusted expected sales for the season, the difference having the purpose of correcting part of the existing imbalance in inventories. The coefficient $1/\sum_{j=1}^{i}\gamma_j$ measures the fraction of the initial imbalance in inventories that is scheduled for correction within the ith season itself; it can be verified that this fraction grows toward an upper limit of one, as the year progresses.

It is apparent from these results that our definitions of "normal" stocks and of "imbalance" in stocks are fully consistent with the common but mostly undefined use of these terms.

5. A TEST BASED ON A CROSS-SECTION OF FIRMS

Hypotheses 20a and 20b can be tested statistically by means of cross-sectional data or by means of time-series data. In our cross-sectional analysis we test whether differences observed at one point of time in the rate of production (or in the level of stocks held) by the different firms included in our sample can be accounted for by corresponding differences in the level of the dependent variables. In time-series tests we test whether variations over time in production (or in level of stocks) can be accounted for by corresponding variations over time in the dependent variables. We have carried out, and are still carrying out, a number of tests of both these types. In this section we shall present the results of one cross-sectional test based on the Dun & Bradstreet survey, and in the following two sections some time-series tests will be discussed.

Most of the Dun & Bradstreet surveys do not readily lend themselves to cross-sectional tests of our hypothesis since they do not supply information on end expectations or on final stocks for the period covered. Furthermore, the information given is not in terms of dollar or physical units, but in terms of percentage changes from the value of the variable at the corresponding time of the year before.

In three of the Dun & Bradstreet surveys, however, the questionnaire was somewhat different. This is exemplified by the August 1949 survey, in which the respondents were asked about (1) stocks at the end of June, (2) stocks at the end of August, (3) expectations at the end of August, and (4) sales in the month of August. All questions, as usual, were in terms of percentage changes from the year before. If we can assume that changes in sales from August 1948 to August 1949 were roughly representative of changes in sales from July and August 1948 to July and August 1949, then we find that we have at our disposal all of the information, except that on initial expectations, required to test equation 21b for a "season" consisting of the months of July and August.

It can be shown that by appropriate algebraic transformations, equation 21b implies a certain relationship between the variables supplied by the Dun & Bradstreet survey. Neglecting some second-order terms, this relationship can be reduced to the following equation:

$$(25)\qquad \frac{H(A)}{H'(A)} = \frac{S_A(Q_4)}{S'(Q_4)} + u\left[\frac{H(J)}{H'(J)} - \left(\frac{a}{a+b}\frac{S(A)}{S'(A)} + \frac{b}{a+b}\frac{S_A(Q_4)}{S'(Q_4)}\right)\right] + v\left[\frac{H'(D)}{S'(Q_4)} \div \frac{H_A(D)}{S_A(Q_4)} - 1\right]$$

or

$$X_1 = X_2 + uX_3 + vX_4$$

where

$\frac{H(A)}{H'(A)}$ = ratio of stocks at the end of August 1949 to stocks at the end of August 1948

$\frac{S_A(Q_4)}{S'(Q_4)}$ = ratio of sales expected in August 1949 for the fourth quarter of 1949 to sales in the fourth quarter of 1948

$\frac{S(A)}{S'(A)}$ = ratio of sales in August 1949 to sales in August 1948

$\frac{H(J)}{H'(J)}$ = ratio of stocks at the end of June 1949 to stocks at the end of June 1948

$\frac{H'(D)}{H_A(D)}$ = ratio of stocks at the end of December 1948 to stocks expected for the end of December 1949

We shall not go into the derivation of this expression, since that involves rather lengthy algebraic transformations; we shall limit ourselves to a brief explanation of the common sense of the various terms entering equation 25.

Referring back to equation 24, we see that for any firm if actual stocks at the end of the ith period are in equilibrium, then they should bear a certain ratio to sales expected at that time for the next period. If we could assume that, for every firm responding to the Dun & Bradstreet survey of August 1949, stocks were in equilibrium in both August 1948 and August 1949, then

$$\frac{H(A)}{H'(A)} = \frac{S_A(Q_4)}{S'(Q_4)}$$

This accounts for the first term on the right-hand side of equation 25. However, this equality will not hold if stocks were out of equilibrium in either August 1948 or August 1949. The remaining two terms in equation 25 together provide for the effect of such disequilibria.

The last term is a measure of the extent to which stocks were out of equilibrium at the end of August 1948. Suppose that these stocks were too high; then we should expect that stocks at the end of December 1948 would still be somewhat above equilibrium. Now we assume that the level of stocks planned in August for the end of December 1949 is approximately in line with the August anticipations of sales for the fourth quarter of 1949, $S_A(Q_4)$, so that the ratio $H_A(D)/S_A(Q_4)$ can be taken as a measure of the equilibrium ratio of December stocks to fourth-quarter sales. Then if the ratio

$H'(D)/S'(Q_4)$ is larger than this equilibrium ratio, so that the quantity

$$\frac{H'(D)}{S'(Q_4)} \Bigg/ \left[\frac{H_A(D)}{S_A(Q_4)} - 1\right]$$

which is the last variable in equation 25 is positive, this can be taken as an indication that stocks at the end of December 1948 and therefore at the end of August 1948 were excessive, and vice versa. Furthermore, since excessive stocks in August 1948 should tend to reduce the ratio $H(A)/H'(A)$, we should expect that the coefficient of this last term will be negative. Similarly, the remaining term in equation 25 is a measure of the extent to which stocks at the end of June 1949 were out of equilibrium. It is an essential feature of our model that errors in stocks are corrected gradually over the fiscal year; hence, other things being equal, excessive (deficient) stocks in June 1949 should lead to excessive (deficient) stocks in August 1949. It follows that the coefficient of this variable should be positive.

It should be noted that in this test particular interest centers in the first and third independent variables. Interest in the first variable arises from the fact that this is a measure of expectations; the third variable, on the other hand, is interesting because it involves the use of *planned* levels of stocks as a measure of excess or shortage of stocks.

We present here the results secured for one selected industry, namely, apparel. In the August 1949 survey this industry had the largest number of respondents, totaling 75, and of these, 46 answered all the questions that were necessary to carry out our test. Our sample consists of these 46 respondents. Our least squares estimation of the parameters of equation 25 yields the following results:

$$\begin{aligned} X_1 = \underset{(\pm 0.10)}{0.95X_2} + \underset{(\pm 0.08)}{0.48X_3} - \underset{(\pm 0.05)}{0.21X_4} + 0.01 \\ R = 0.88 \end{aligned}$$

These results obviously are gratifying. The signs of the coefficients are all as expected and the least significant coefficient, that of X_4, is still over four times its standard error. The constant term differs insignificantly from zero; and the coefficient of the variable X_2 is close to the value of one, which we had anticipated on the basis of our hypothesis. The multiple correlation coefficient is also uncommonly high for cross-sectional data, and for a fairly large sample.

Similar computations are in progress for samples of other industries in this and other surveys, but the results are not yet ready to be presented.

The test we have discussed so far, it will be noted, is primarily a test of whether our fundamental model, expressed by equations 10 and 25, is tenable and of whether expectations are "relevant" in the sense defined earlier. It is not directly a test of the forecasting value of expectations and plans, primarily because we do not have in this survey a direct measure of initial anticipations. In the two time-series tests that follow we shall focus more directly on the question of the use of expectations for short-term forecasting.

6. Time-Series Test: Production and Inventory Movements in Manufacturing Industries—A Case Study of the Cement Industry

The shippers' survey supplies us with quarterly anticipations of shipments expressed in volume terms (number of carloads). If we define the seasons of the year as four three-month periods, we have at our disposal information on beginning and end expectations and actual shipments for some ninety periods between 1928 and 1950.

In order to exploit the shippers' survey for a test of our hypothesis and for the estimation of the relevant parameters, we also need, however, information on production and stocks on a monthly or, at the very least, on a quarterly basis. Unfortunately, such information is rather scanty. Moreover, the survey relates only to the fraction of total shipments that travel by rail; this is a serious source of difficulty and suggests the desirability of using industries for which this method of transportation is predominant. It would also be desirable to deal only with industries that manufacture a fairly homogeneous product, so that carload shipments provide a reasonably good measure of sales.

We have been able to identify only one industry, the cement industry, that fulfills all of the above requirements reasonably well, and two others, petroleum and lumber, that meet them rather imperfectly. In the case of the petroleum industry the major shortcoming is that the proportion of shipments normally transported by rail is not large. In the case of the lumber industry the commodity group "lumber and forest products" in the shippers' survey does not coincide with the comparable industry for which statistics on production and stocks are available. For these reasons our analysis is most advanced for the cement industry.

Another difficult problem arises in connection with the timing of the shippers' survey. As we have indicated earlier, the respondents are asked to forecast a given calendar quarter four to six weeks before the beginning of the quarter. If we define the seasons as calendar quarters, then we have a measure of expectations for each season. But we have expectations held not at the beginning of this season, but some six weeks before, and in dealing with three-month periods a six-week difference is a very large one. On the other hand, if we define each season as a three-month period, beginning at a point of time as close as our data will permit to the time at which the survey is conducted, then we shall have beginning and end expectations; however, these expectations will not refer to the season as defined but to an overlapping calendar quarter.

Thus the first definition implies the doubtful assumption that a constant relationship exists between expectations held at a six-week interval for the same future period, and the second definition implies that there is a constant relationship between expectations held at the same point of time for two successive and partly overlapping periods. Since this latter assumption seems less objectionable than the previous one, we have adopted the second definition for our seasons. Because each survey is conducted around the middle of a calendar month, while the figures at our disposal are for calendar months, we must still decide whether the season should begin with the month of the survey or with the following month. This decision should be made so as to maximize the conformity of the beginning of the seasons with the major planning dates in the industry under consideration.

In the case of the cement industry we secured information on the major planning dates and more generally on the entire planning procedure by means of personal interviews with the management of a few firms in the Chicago area. (We realize, of course, that the Chicago area may not be representative of conditions in other parts of the country.) We then defined the season as the three-month period beginning two months before the calendar quarter covered by the forecast. Thus the seasons are defined as consisting of the three-month periods beginning, respectively, with the months of November, February, May, and August. In this way the beginning of the year for our model, November 1, coincides with what the industry seems to consider the beginning of its shipment year.

The results we present in this paper are based on the above definitions of the seasons. However, before we complete our analysis of this industry we shall test the effects of changing the definitions. Some experiments in this direction are already in progress.

Only a few words are necessary concerning the sources of the data. Information on stocks and shipments is taken from the cement section of the *Minerals Yearbook.* Stocks represent the sum of cement and clinker stocks. As for production, there is some question as to whether one should use cement production, clinker production, some average of the two, or some other measure. Since it is of some importance in our case that the variables we use should satisfy exactly the fundamental identity, we have defined production as shipments plus increase in stocks.

There remains the problem that expectations are expressed in carload units while stocks are reported in barrel units. Further, expectations refer only to that part of total shipments that goes by rail. According to available information this proportion has been at all times very high, usually between 80 and 85 per cent.

Now errors in the shippers' forecasts might arise from any of the following three factors: (1) an error in estimating the total amount of cement to be shipped, (2) an error in estimating the proportion of this total to be moved by rail, and (3) an error in estimating what we shall call the "conversion factor," i.e. the number of carloads necessary to move the number of barrels shipped by rail. When, as in the case of the cement industry, the overwhelming proportion of the output moves by rail, and the number of barrels per carload changes very little, at least in the short run, then the most important component of an error in a forecast must be the first of the three factors, which is the only one in which we are now interested. If we could assume that the error of the forecast is due exclusively to this factor, then we could measure the error of anticipation for total shipments by the ratio of anticipated to actual carloads. In this case anticipated total shipments in barrels could be computed for any given quarter by multiplying the actual number of barrels shipped in that quarter by the ratio of anticipated to actual carloads in that quarter.

Since, in fact, it is likely that the shippers are not able to anticipate fully the small observed changes over time in the conversion factor, we used a slightly more complex procedure. An estimate of anticipated total shipments in barrels was computed in two ways: by the formula described above and by applying to anticipated carloads the conversion factor actually observed in the corresponding quarter of the year before. (The reason for taking the corresponding quarter of the year before is that there is some evidence of a slight seasonal pattern in the conversion factor.) The simple average of the two estimates was then used as the measure of anticipated total shipments; the series thus obtained differs from the one obtained by the method first described only to the extent of eliminating certain minor apparent abnormalities.

It has already been shown in section D 2 that a basic feature of our hypothesis is that the relation between production and the variables presumably determining it may be expected to change from one season to another.

For the presentation of our empirical results it will be convenient to define certain symbols. These symbols are defined in terms of the first season of the year. The adaptation to the remaining seasons will be obvious:

X_{1t} = production in November and December of the calendar year $t-1$ and January of the year t
X_{2t} = stocks as of October 31 of the year $t-1$ (beginning stocks)
X_{3t} = anticipations in November of the year $t-1$ for the first calendar quarter of the year t (initial anticipations)
X_{4t} = shipments in the months of November and December of year $t-1$ and January of the year t
X_{5t} = anticipations in February of the year t for the second calendar quarter of the year t (end anticipations)

All variables are measured in millions of barrels.

The coefficients of our equation have been estimated basically by least squares. A special problem arises, however, when the equation involves a switching coefficient, i.e. when d of equation 15 has the value one for some of the observations; in this case we must estimate the function f of equation 15. This function f we shall refer to as the "auxiliary equation." The difficulty is that in order to determine f we must first know the value for d for every observation, but this depends on P^*, which can be evaluated only after we know the observations for which d is equal to zero.

We have handled the above problem by an iterative procedure. First, we determined by inspection which years are not likely to require the auxiliary equation. Equation 10 is fitted to these observations. From this first estimate we now compute P^* and check whether we were correct in our estimate of the years that should be included. If we should find significant errors in our first guess we would then use our estimate of P^* to decide which years should be included. We then secure a second estimate of P^*, and so on. In fact, however, we did not find it necessary to proceed to even the second step in this iterative procedure.

For the first period it appears that an auxiliary equation is required for the years 1942 and 1947-1949 (the year 1946 is a borderline case). The reasons justifying the use of the auxiliary equation and the nature of this equation are best given at a later point. Accordingly, our hypothesis 10 was tested for the remaining eighteen years—1928 to 1941 and 1943 to 1946.

Let us examine the zero-order correlation matrix obtained for our five variables, X_1 to X_5, for the eighteen years just mentioned, shown in table 11. The correlation between production and ship-

TABLE 11

Zero-Order Correlation Matrix, Cement Industry, Season I

Years Satisfying the Principal Equation (1928-1941 and 1943-1946)

	X_2 (*Initial Stocks*)	X_3 (*Initial Anticipation*)	X_4 (*Shipments*)	X_5 (*End Anticipation*)
X_1 (production)	−0.71	0.969	0.938	0.86
X_2 (initial stocks)		−0.67	−0.72	−0.33
X_3 (initial anticipation)			0.925	0.80
X_4 (shipments)				0.70

Source: Based on data of Regional Shippers' Advisory Boards, Association of American Railroads.

ments is rather high (0.938), though the size of our coefficients must be heavily discounted since we are dealing with time-series over a period characterized by wide fluctuations. However, the correlation of production with initial anticipations is impressively higher (0.969). In other words, initial anticipations are more important in forecasting production than perfect foreknowledge of shipments.

The correlation of initial anticipations with actual shipments is also very high (0.925), indicating that in this quarter expectations tend to be fairly closely in line with actual later shipments; note, however, that this cannot be taken as a direct measure of forecasting accuracy because the period forecasted does not coincide with the period covered by the shipments. The correlation between initial and end anticipations, on the other hand, is not so high, suggesting that sizable revisions in anticipations can occur within a span of three months.

Finally, we might point to the remarkably low correlation between shipments and end anticipations (0.7). This low coefficient is certainly inconsistent with the hypothesis that sales anticipations are mere extrapolations of the most recent sales experience. However, this subject belongs to the study of the formation of expectations, which we cannot cover here.

It will be interesting to look next at the regression of production on shipments and initial stocks. This regression embodies in a sense the traditional approach, since it involves only conventional, *ex post* variables. It turns out that the partial correlation of production with initial stocks, though negative as expected, is nonetheless of negligible magnitude (–0.15), and the multiple correlation amounts to only 0.94. If we substitute initial anticipations for actual shipments the partial correlation of stocks is somewhat higher and the multiple correlation is a great deal higher, namely 0.971. In other words, while in the previous case we explained 88 per cent of the variance, by using anticipated instead of actual shipments we account for 94 per cent.

So far we know that we can make a fairly good forecast of production on the basis of information on initial anticipations and stocks. The question we may raise next is: To what extent could we improve this forecast if we were able to forecast precisely forthcoming shipments? This question may be answered by looking at the partial correlation of production with shipments. It turns out that information on actual shipments would reduce by only 14 per cent the amount of variance not already accounted for by anticipations and stocks. But one might raise the question the other way around. Suppose one had a good forecast of forthcoming shipments as well as information on initial stocks. How much would one gain in terms of forecasting ability by knowing initial anticipations? The partial correlation of production with anticipations turns out to be 0.77, which means that such information would reduce by approximately 60 per cent the variance not accounted for by actual shipments and stocks. Thus information on initial anticipations turns out to be significantly more useful in forecasting production than in forecasting shipments. Indeed, information on actual shipments does not significantly improve our ability to forecast.

Having highlighted these interesting conclusions, we can proceed to a complete test of our hypothesis by introducing end expectations as a fourth independent variable. The final regression equation, with standard errors of regression coefficients, is as follows:

$$(26) \qquad X_1 = -0.50X_2 + 0.52X_3 + 0.43X_4 + 0.32X_5 + 9.0$$
$$(\pm 0.09) \quad (\pm 0.13) \quad (\pm 0.11) \quad (\pm 0.04)$$
$$R = 0.996$$

These results are again obviously satisfactory. The significance of every one of the regression coefficients exceeds considerably the 1 per cent level, and the multiple correlation is uncommonly high even for time-series analysis. Our variables account for over 99 per cent of the variance in production. We might note in particular that the end anticipations turn out to have the highest partial correlations (0.92).

It would be interesting at this point to carry out a detailed analysis of the regression coefficients to see how well they agree with what we might expect on the basis of our model. But space prevents us from making such an analysis, which would be rather time-consuming here, especially in view of the modifications of the model necessitated by the form and limitations of the data used. If the reader carries out this analysis, he will find that the coefficients for initial stocks and shipments are somewhat higher than our hypothesis would imply. This suggests that production in the first season is perhaps not exclusively keyed to the entire shipment year, and is more influenced by current developments than our model assumes.

One word now about the switching device and auxiliary equation for the first season. In the first season of the year, and especially in December and January, it is normal for the cement industry to cut its production considerably for various reasons. We find that in every one of the years in which X_1^* (i.e. the value of X_1 computed from equation 26) exceeds significantly 90 per cent of production in the previous season, production itself falls considerably short of X_1^* and is approximately equal to 90 per cent of the previous season's production plus 30 per cent of the excess of X_1^* over that amount. Hence our switching coefficient for this period is defined as taking the value one, if, and only if, X_1^* exceeds 90 per cent of the previous season's production. Our auxiliary equation takes the form

$$(27) \qquad X_1 = 0.9X_1(\mathrm{IV}) + 0.3[X_1^* - 0.9X_1(\mathrm{IV})]$$

where $X_1(\mathrm{IV})$ denotes actual production in the previous season. The coefficient 0.3 was estimated by inspection. The auxiliary equation fits the data fairly well, though not too much significance can be attached to this in view of the very small number of degrees of freedom. Our production equation for season I finally takes the form

$$(28) \qquad X_1 = (1-d_1)X^*_1 + d_1\{0.9X_1(\mathrm{IV}) + 0.3[X^*_1 - 0.9X_1(\mathrm{IV})]\}$$

where $X^*_1 = -0.50X_2 + 0.52X_3 + 0.43X_4 + 0.32X_5 + 9.0$
$d_1 = 1$ when $X^* \geq 0.9X_1(\mathrm{IV})$
$= 0$ otherwise

The proportion of the original variance accounted for by equation 28 is 99 per cent, which is equivalent to a multiple correlation of 0.995. This figure is not, however, a multiple correlation coefficient, for our equation was not entirely estimated by least squares. (See also chart 5.)

We proceed now to a quick review of the results for season II. For this season limitation of capacity requires the use of a switching device for the years 1947, 1948, and 1949. For the remaining nineteen years we find that the simple correlation of production with anticipations is now much lower, namely 0.90, and is now lower than the correlation with shipments, 0.93. As expected, initial stocks play a more prominent role in this season. The multiple correlation of production with shipments and stocks is 0.966 and is equal to the multiple correlation of production with initial expectations and stocks. Thus, also in this season, perfect foreknowledge of shipments would not by itself enable us to forecast any better than we could from beginning anticipation and stocks. However, the addition of actual shipments to initial anticipation and stocks reduces by 56 per cent the unexplained variance. In other words, ability to forecast shipments perfectly in this season would help somewhat to improve our forecast of production. At the same time, initial anticipations also explain 56 per cent of the variance not accounted for by shipments and stocks; thus knowledge of initial anticipations would once more help significantly to improve our forecast, even if we were able to make a perfect forecast of shipments.

The multiple correlation when all three variables are used simultaneously is 0.986. However, end anticipations do not have a significant influence after the other variables have been taken into account. The partial correlation is only 0.2, which is not significantly

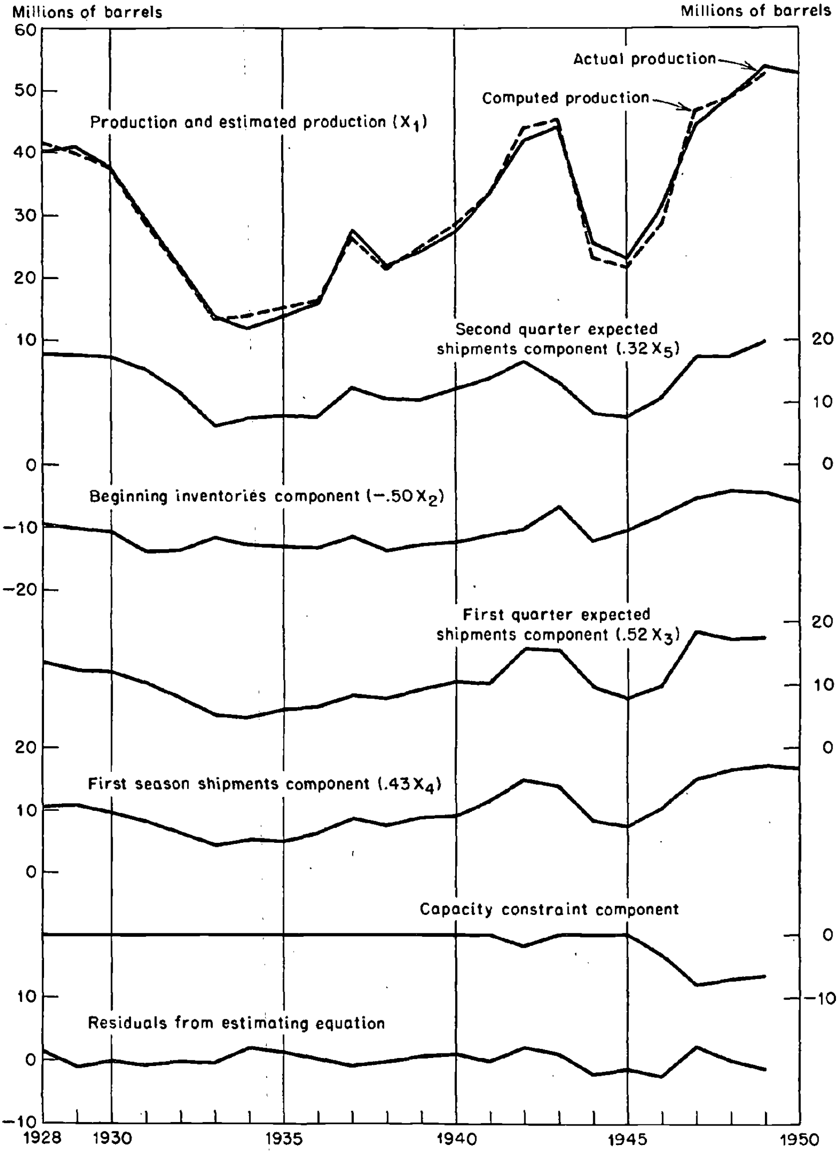

Chart 5. Factors "Explaining" Production, Cement Industry, First Season of Each Year (November, December, January), 1928-1950

different from zero. Our regression equation, dropping end anticipations, is

$$X_1 = -0.30X_2 + 0.51X_3 + 0.59X_4 + 22.8 \qquad R = 0.985 \tag{29}$$
$$(0.22) \quad (0.11) \quad (0.13)$$

Coming now to the auxiliary equation, it appears that in this season the critical upper level of utilization is in the order of 60 per cent of theoretical capacity. For every one of the four years in which X_1^*, i.e. the estimated value of X_1 computed from equation 29, exceeds 60 per cent of capacity, we find that actual production fell significantly short of X_1^*; this drop occurs in 1947, 1948, and 1949, and to a minor extent in 1942. Our switching device therefore goes into effect whenever X_1^* exceeds 60 per cent of capacity. Our auxiliary equation estimated by inspection is:

$$X_1 = 0.6\,P^c + 0.8\,(X_1^* - 0.6\,P^c) \tag{30}$$

where P^c denotes the output capacity as estimated by the Bureau of Mines. Our final equation for the second season, therefore, can be written as

$$X_1 = (1-d_2)X_1^* + d_2[0.6P^c + 0.8(X_1^* - 0.6P^c)] \tag{31}$$

where $d_2 = 1$ when $X_1^* > 0.6P^c$
$= 0$ otherwise

The proportion of total variance of production accounted for by the right-hand side of equation 30 is 98 per cent.

For the last two seasons our analysis is not yet sufficiently advanced to warrant presentation at this time. Preliminary results suggest that expectations, especially end expectations, play a less important role. This is, of course, not inconsistent with our hypothesis, as we have shown in section D 4, especially when account is taken of the actual periods to which these expectations overtly refer. In conclusion, the results of the tests carried out so far for the cement industry appear to be consistent with our model and to support the hypothesis that expectations are both relevant and useful in forecasting, although these results cannot be considered as definitive.

7. Time-series test: inventory fluctuations in the postwar period

The major purpose of the last test we shall report here is to determine whether anticipations as measured by the *Fortune* and the

Dun & Bradstreet surveys can help us to account for the observed fluctuations in stocks in the postwar period. Once more we are interested in testing whether anticipations, as measured by these surveys, are meaningful and whether the information reported might be exploited for short-term forecasting. Such tests are planned for all the major industries in which inventories play a significant role and for which the relevant information is available. We shall present here some preliminary results of tests carried out for all nondurable goods manufacturing industries.

Our basic expectations data are derived from the *Fortune* survey, which supplies us with information for eight points of time between the end of 1946 and the middle of 1950. These expectations, it will be remembered, refer to calendar half years, beginning about six weeks after the survey is taken. Now we have reason to believe that expectations may undergo substantial changes in the interval of seven and one-half months between the survey and the end of the period to which the expectations refer; some evidence supporting this has been brought out in previous sections. For this reason, and because our interest here is in testing the use and relevance of expectations for short-term forecasting, we shall assume that the expectations reported may be used as a measure of short-term expectations for the three-month period beginning with the calendar month immediately following the survey. Our problem is to explain the level of inventories at the end of this period.

The reason for choosing end inventories, rather than production, as our dependent variable is that we have directly available monthly estimates prepared by the Department of Commerce of aggregate dollar inventories and sales of this industry, whereas there is no corresponding information on production.

As long as we use *Fortune* as our only source for expectations we have only eight observations to rely upon, an exceedingly small number, especially when we are attempting to test a hypothesis involving three independent variables. It will be recalled that in section C we presented some evidence and arguments in support of a hypothesis that the unadjusted response to the Dun & Bradstreet survey can be taken as a measure of short-term anticipations roughly comparable to the *Fortune* responses. On the basis of this hypothesis it appeared worth while to enlarge our sample by exploiting the returns of the Dun & Bradstreet surveys taken at points of time differing by at least two months from the nearest *Fortune* surveys. There are three such surveys, those of September 1949, February 1949, and July 1950. These increase our sample from eight to eleven, a most welcome addition. For these three surveys the period of analysis consists again of the three-month period beginning with the first month following the survey.

Before proceeding to the test we must still face several serious difficulties raised by the nature of the data. One important feature of our basic hypothesis is that the relation between end inventories (or production) and the relevant independent variables changes from one season to another. This is why in the cement industry test we treated each quarter of the year separately. In the present case, however, the series is so short that we have no choice but simultaneously to base our statistical test on the observations for all seasons. This procedure can be justified only if the coefficients of the equation to be tested can be assumed to be approximately constant from season to season. Strictly speaking, this assumption is not justified; there is reason to believe, however, that the error involved in this assumption can be minimized by the use of seasonally adjusted data, which are also available in this case.

It can be shown that our basic equation 21b implies a linear relation between seasonally adjusted inventories, expectations, and sales of the form

$$(32) \qquad \bar{H}(i) = A\bar{S}_{i-1}(i; i-1) + BS(i; i-1) + D\bar{H}(i-1) + E[\bar{S}_i(i+1; i) - \bar{S}(i; i-1)]$$

The barred symbols in this equation represent seasonally adjusted variables. Seasonally adjusted sales and expectations at annual rates are defined as in section D 4. Hence, for the model now being tested we have[31]

Seasonally adjusted sales; $\bar{S}(i; i-1) = \dfrac{S(i; i-1)}{4s_i}$

Seasonally adjusted initial expectations; $\bar{S}_{i-1}(i; i-1) = \dfrac{S(i; i-1)}{4s_i}$

Seasonally adjusted end expectations; $\bar{S}_i(i+1; i) = \dfrac{S_i(i+1; i)}{4s_{i+1}}$

As for seasonally adjusted stocks, they are defined as follows:

$$\bar{H}(j) = H(j)\frac{c''}{K_j}$$

[31] The figure 4 appears as a divisor in these definitions since quarterly data are being used.

where K_j is defined by equation 22 and represents the "normal" ratio of stocks at the end of season j to expectations for the balance of the year at seasonally adjusted annual rates, while c is the average value of K_j, i.e.

$$c'' = \frac{1}{4} \sum_{j=1}^{4} K_j$$

It can be shown to follow from our model that $c = 4c''$ represents the normal ratio of seasonally adjusted stocks to seasonally adjusted quarterly sales, which ratio turns out to be a constant independent of the season. The coefficients A, B, D, and E of equation 32 can be further expressed in terms of the various parameters defined in sections D 2 and D 4, by means of the following relationships:

$$(33) \quad \begin{cases} A = (1-am)\left[c(1-b_i) + \dfrac{cs_i}{K_i}\right] \\ B = amc(1-b_i) - (1-am)\dfrac{cs_i}{K_i} \\ D = b_i \\ E = am\dfrac{c}{K_i}\Gamma_i(\sigma_{i+1}s_{i+1} + \beta s_z) \end{cases}$$

Of the various symbols appearing on the right-hand side of these equations c and K_i have just been defined; Γ_i, σ_i, and β have been defined in sections D 2 and D 4 (see equations 13, 18b, and 20); and b_i stands for the following expression:

$$b_i = \frac{(1-\Gamma_i)K_{i-1}}{K_i}$$

It can be shown that the quantity $(1-b_i)$ represents the fraction of the imbalance in initial inventories (in seasonally adjusted terms) that is scheduled for correction in the ith season.

For a complete test of equation 32 we should have information on end period expectations, $S_i(i+1; i)$. Unfortunately this information is not available in the present case since the *Fortune* surveys are at six-month intervals and we have found it desirable to define our seasons as three-month periods. In order to salvage our test we have to fall back on the assumption that the missing information on end expectations can be approximated in terms of actual sales within the period, i.e. that $\bar{S}_i(i+1; i) \cong \bar{S}(i; i-1)$, so that the last term of equation 32 drops out. This assumption, of course, will imply an error, but we may hope that this error is not too large and can be included in the unexplained variance without seriously affecting the estimates of the remaining coefficients.

Even with the heroic decision above, our difficulties are not entirely over. It will be seen that every one of the coefficients A, B, and D that still appear in equation 32 unfortunately cannot be expected to be constant from season to season because they involve seasonally dated quantities like b_i, s_i, and K_i. If we take into account that even the feed-in coefficient *am* may vary from season to season, then c appears to be the only coefficient that may be expected to be seasonally constant. Thus even if the available data were seasonally adjusted in accordance with our definitions (which is of course very doubtful), it would still be desirable to treat each season of the year separately in testing our hypothesis. This is a very uncomfortable conclusion, since the shortness of the series precludes our treating each quarter separately. It must be noted, however, that our conclusion about the seasonal nature of the coefficients applies directly only to a single industry. In the present test we are dealing with a large aggregate of industries whose seasonals are not coincident and therefore partly cancel out. For any individual industry the average value of any seasonal coefficient over all seasons of the year is obviously a constant. By the same token, if the various industries we are aggregating are in different phases of their seasonal pattern at any given point of the calendar year, then it may be hoped that a cross-sectional average of their seasonal coefficients will possess a certain stability. It is with this hope that we proceed to a test of hypothesis 32 (with the omission of the last term), by means of the data described earlier.

The information on seasonally adjusted stocks and sales required for this test was taken directly from the published series of the Department of Commerce.[32] For expectations we use the survey data without further adjustment, since these expectations are supposed already to be expressed in seasonally adjusted terms.

For the purpose of carrying out the test one further transformation was introduced in equation 32. The terms $\bar{H}(i)$ and $\bar{H}(i-1)$, measuring as they do inventories *adjusted* for seasonal variation at only three-

[32] For the years 1946 through 1949, *Survey of Current Business* (Department of Commerce), October 1950, pp. 20-21; for 1950, current issues of the same publication.

month intervals, are bound to be highly intercorrelated to the point where they would tend to yield a misleadingly high multiple correlation and affect the reliability of our estimates of the other coefficients. We prefer, therefore, to transform our dependent variable from the actual level of inventories to the rate of change of inventories, which can easily be done by dividing both sides of the equation by initial inventories. This has the added important advantage of reducing by one the number of variables and thus giving us one more degree of freedom. The resulting equation 34 was then used in our test:

$$\frac{H(1)}{H(0)} = a'\frac{S_0}{H(0)} + b'\frac{S(1;0)}{H(0)} + c' \tag{34}$$

where 1 and 0 denote respectively the end and beginning of each period. The three variables will be denoted respectively by X_1, X_2, and X_3.

The zero-order correlation matrix for these three variables is given in table 12.

TABLE 12

Zero-Order Correlation Matrix, *Fortune* and Dun & Bradstreet Combined Series

	X_1	X_2	X_3
X_1		0.871	0.77
X_2			0.74

Source: Based on data of *Fortune* magazine and Dun & Bradstreet.

The two striking features of this zero-order table are:

1. Initial anticipations account by themselves for a large proportion of the variance in the rate of change of stocks, about 76 per cent. This is true even though anticipations are only moderately well correlated with actual shipments. (The correlation of 0.74 between these variables cannot be taken, however, as a direct measure of accuracy of anticipations in the sense of section C because both anticipations and sales are here divided by the same variable, H[0].)

2. The correlation with anticipations is impressively larger than that with actual shipments; the latter variable accounts for only 59 per cent of the variance of the rate of change of stocks as against 74 per cent for anticipations. When we use both anticipations and actual sales as independent variables the partial correlation of an-

ticipations still remains fairly large, 0.70 (which is significant at the 2 per cent level by standard tests). In other words, even if we have a perfect forecast of sales, knowledge of anticipations accounts in the period of observation for 50 per cent of the residual variance. On the other hand, the partial correlation of actual shipments falls to a rather insignificant level, 0.39 (which is not significant at the 5 per cent level). Thus if we have knowledge of anticipations, even a perfect foreknowledge of sales does not significantly improve our ability to forecast investment (or disinvestment) in inventories. The regression equation takes the form

$$(35) \qquad X_1 = \underset{(\pm 0.06)}{0.19X_2} + \underset{(\pm 0.05)}{0.06X_3} + 0.53$$

but our estimate of these coefficients, especially the second, is unfortunately subject to large error.

It is of some interest to utilize these estimates to obtain in turn estimates of the parameters appearing on the right-hand side of equation 33, which have a more direct meaning in terms of the decision process. This can be done by solving equation 33 for these parameters, in terms of our estimates of the coefficients A, B, and D. To the extent that these parameters are seasonally dated, the estimates obtained in this way are to be regarded as estimates of their average value, the average being taken both over a cross-section of industries and over the seasons of the year.

Since there are six distinct parameters on the right-hand side of the relevant equation 33 and only three equations, we cannot estimate each parameter separately. Two of these parameters, however, can be obtained independently of the remaining one, namely:

$$b = D = 0.53$$

$$c = \frac{A + B}{1 - b} = \frac{0.25}{0.47} = 0.52$$

The second of these parameters, it will be recalled, measures the normal or desired ratio of stock to sales; our results suggest that the normal level of stocks for the nondurable goods industries is slightly over one-half of one period of sales or one and one-half months of sales (since our period consists of three months). This estimate appears extremely reasonable, as an inspection of the data on sales and stocks will easily reveal.

As for b, it will be recalled that this coefficient, or more precisely the quantity $(1-b)$, is a measure of the speed with which inventories imbalance tends to be corrected. Our numerical estimate indicates that, on the average, the industries under consideration plan to correct in a three-month period approximately one-half of any imbalance in inventories in existence at the beginning of the period. This estimate, too, appears reasonable, since it can be shown that a priori considerations suggest that this coefficient should be precisely in the order of one-half.[33]

It would, finally, be interesting to obtain an estimate of the feed-in coefficient *am*. The equation 33 implies the following relation:

$$am = \frac{B + c\dfrac{s}{K}}{(A+B) + c\dfrac{s}{K}}$$

In order to estimate *am*, therefore, we need to know the value of s/K, which in turn should represent some average of the values of s_i/K_i over industries and over seasons.

While we have no direct information about it, it can be shown to follow from the definitions of c, s, and K that the value of the quantity $c(s/K)$ should be unity if the seasonals of the different industries offset each other and that it is unlikely to depart very much from unity unless the seasonal in production and sales is sharp. If we take a value of around unity as a rough guess, then our feed-in

[33] As we have argued, the value of b derived from the regression equation should not be very different from the average value of b_i over all seasons of the year. If we look at the definition of b_i we see that this coefficient represents the product of two factors; the second of these factors, K_{i-1}/K_i, represents essentially the ratio of normal stocks at the beginning to normal stocks at the end of each season and, therefore, should not be very different from unity if the seasons are not too long. Next consider the first factor

$$1-\Gamma_i = \frac{\sum_{j=1+i}^{s} \gamma_j}{\sum_{j=1}^{s} \gamma_j}$$

If all the γ's were equal (i.e. if production were planned at an even rate through the year) then $1-\Gamma_i = z-(i)/z-(i-1)$. Hence if we are dealing with four seasons per year so that i takes values from 1 to 4, the average value of $1-\Gamma_i$ will be $\frac{1}{4}(\frac{3}{4} + \frac{2}{3} + \frac{1}{2} + 0) = 0.48 \cong 0.5$. If the γ's increase in the course of the year, as is likely to be the case, the average will be higher; but unless the seasonal is pronounced it is not likely to exceed an upper limit of, say, 0.6. Hence the product of the averages of the two factors should be in the order of 0.5 to 0.6. Finally, we may observe that since inventories will typically rise in the early part of the year and fall thereafter, the second factor will tend to be above average when the first is below average; this negative correlation will tend to depress somewhat the average product. On the whole, then, we are led to expect an average value of b_i of about 0.5.

coefficient would appear to be in the order of 0.8. This is a high figure for a three-month period, but note that we have been getting very similar estimates for the cement industry. It is this high value of the feed-in coefficient that accounts for the fact that the coefficient of sales is positive in equation 35. At first this result might appear disturbing, because, according to our hypothesis, the coefficient of sales in the stock equation should be negative. This is true, however, only if end expectations are included explicitly in the equation. In the present case actual sales are also a "proxy" for end anticipations, and therefore have a double influence on stocks. On the one hand, they are a drain on stocks, and to this extent the coefficient of this variable should be negative; on the other hand, insofar as this variable provides proxies for end expectations, its effect on stocks will be positive, since it will tend to bring about a revision in the production plan in the same direction. The strength of this positive effect depends, of course, on the feed-in coefficient. In the present case the feed-in coefficient seems to be large enough to cause the positive effect to outweigh the negative one, though by a very slight margin. That is to say, it would appear that firms manage to revise production sufficiently to take care of unanticipated changes in sales, but not sufficiently to change end inventories significantly from the level originally planned.

In conclusion, therefore, this last test again suggests that information on anticipations supplied by the postwar surveys is both relevant and useful in forecasting inventory movements; in fact short-run movements in this variable appear to be forecastable to a considerable extent by means of this information alone (plus initial stocks). This is, indeed, an encouraging conclusion even if it is but a tentative one, since the forecasting of short-run inventory movements is usually considered one of the most difficult tasks in short-term forecasting.

It has been the purpose of this paper to test whether surveys of business expectations are likely to be useful in forecasting. Our results, so far, are encouraging even though they are based on data that are not the kind we ourselves would have collected for the purpose. We can only hope that further and more extensive tests will broadly confirm these preliminary results.

Appendix

TABLE A-1

Median Anticipated Percentage Changes in Sales, *Fortune* Survey

Date of Survey	*Period to Which Forecast Refers*[a]	*Base Period*[a]	*Durable Goods*[b]	*Nondurable Goods*[b]	*Wholesale Trade*[b]	*Retail Trade*[b]	*Private Sector, National Income (Implicit)*[c]
Nov. 1946	IH 1947	IIH 1946	4.5 (789)	2.0 (542)	0.0 (000)	0.0 (000)	2.6
May 1947	IIH 1947	IH 1947	—3.0 (1,192)	—4.0 (779)	—5.7 (402)	—2.0 (384)	—3.2
Nov. 1947	IH 1948	IIH 1947	3.2 (1,313)	3.0 (791)	1.7 (421)	2.0 (441)	2.7
May 1948	IIH 1948	IH 1948	2.0 (1,349)	2.7 (822)	2.7 (482)	4.0 (393)	3.2
Nov. 1948	IH 1949	IIH 1948	—3.3 (1,192)	—3.7 (740)	—4.5 (406)	—3.2 (411)	—3.2
May 1949	IIH 1949	IH 1949	—7.7 (1,348)	—5.2 (756)	—7.0 (373)	—6.4 (416)	—6.2
Nov. 1949	IH 1950	IIH 1949	2.2 (1,190)	2.2 (780)	—1.0 (327)	—2.4 (363)	0.7
May 1950	IIH 1950	IH 1950	3.2 (1,252)	2.7 (811)	3.0 (328)	1.0 (359)	2.5

[a] IH = first half, etc.
[b] Figures in parentheses indicate the number of observations from which the medians were computed.
[c] For a description of the method used in estimating the figures in this column see section C 2.
Source: Compiled from data of *Fortune* magazine.

COMMENT

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This paper by Modigliani and Sauerlender is long, interesting, and incomplete. Full and balanced assessment of an empirical study like this must await revelation of much of the background material, which is promised for studies to be released by the Bureau of Business Research at the University of Illinois. These comments will, therefore, be fragmentary and selective and directed toward some of the more novel and interesting findings and ideas contained in the paper.

The analyses of existing expectations data undertaken in this study are valuable for the light they throw on business behavior. Among other matters of interest, to which attention has already been addressed at this Conference,[1] is the question of how forecasts by professional economists compare with those by businessmen. Much more needs to be done before this question can be discussed unequivocally. For example, the need for forecasting accuracy of the professional group and that of the business group should be compared both in terms of the problems to be solved by such forecasts and the (e.g. administrative) mechanisms available to each of the groups for corrective action in the event of mistaken forecasts. Intimately involved in this question are the differences, as well as relations, between forecasting for scientific and forecasting for "practical" purposes. The two are not in all respects comparable; and differences as well as similarities should be recognized in arriving at an assessment. The farmer, with smokepots available in his orchard, needs to meet, for his limited purposes, less exacting requirements in his forecasts of the weather than does the meteorologist in his general-purpose analyses of the weather. The farmer's tolerances are wider and vaguer, requiring him merely to turn the smokepots up or down, more or less, and except at certain critical levels his forecasts do not even have to assume specific numerical form. He can correct, overcorrect, and adjust from moment to moment as he finds conditions altering, and his forecast band is, generally, much shorter than that of the meteorologist. The need for making the forecast and access to corrective instruments will of

[1] See the paper by V Lewis Bassie, "Recent Developments in Short-Term Forecasting," in this volume.

course condition, if not determine, the character and the form of the forecast.

Another matter of some interest revealed by Modigliani and Sauerlender's analyses of expectations data is the critical character of the form of the questions by which the expectations are solicited. Much depends on what the respondent is expected to estimate: experiences of his immediate environment or the vast reaches of gross national product. Much also depends on the bases of comparison to which attention is directed, and the estimating form used. Ratio and absolute estimates seem, *ceteris paribus*, to yield quite different results, as Modigliani and Sauerlender note. The clearest case, perhaps, is the forecasts of the regional Shippers' Advisory Boards of the American Association of Railroads. Here the method of estimating is itself subject to the ordinary bias of a ratio estimate.[2] But more, apparently, is involved than this. Judging from Modigliani and Sauerlender's analyses of Dun & Bradstreet and *Fortune* data on expectations, a psychological, as well as a statistical, bias arises when the questionnaire solicits information in ratio form. Evidently the "stability" of ratios has psychological as well as statistical roots.

But, of course, it may be a mistake to accept such estimates of anticipations by businessmen—or others—at face value. "Practical" people frequently behave more intelligently than they speak or write.[3] Closely related to this point is a question of different types

[2] It is also subject to the bias of a "selected" sample intended to give representation to the large shippers. Even in unbiased sampling, however, a ratio estimate will yield biased results. Thus, if X' = parameter for which an estimate is sought, such as shipments in forthcoming quarter; Y' = base to which ratio is to be applied, such as actual shipments in comparable quarter of preceding year; and XY = sample values of corresponding parameter, then what is sought is

$$X' = \frac{EX}{EY}Y'$$

where the expected value $EX = X'$ and the expected value $EY = Y'$. But the ratio is secured in the form

$$E\frac{X}{Y} = \frac{EX}{EY} - \frac{\sigma_{Y\frac{X}{Y}}}{EY} = \frac{X'}{Y'} - \frac{\rho_{Y\frac{X}{Y}}\sigma_Y \sigma_{\frac{X}{Y}}}{Y'}$$

the amount of bias being given by the last term on the right. Thus in upturns, where one would expect positive correlation, such a method would tend to underestimate true levels, while in downturns, where one would expect negative correlations, such a method would tend to overestimate true levels.

[3] As Modigliani and Sauerlender are careful to note. Estimates that seem to be grossly unsatisfactory to an outsider may prove to be quite satisfactory for practical operating purposes, and their use more satisfactory than allotting the additional time and expense necessary to secure more precise and reliable estimates.

of budgets used by business firms for different purposes. Needless to say, the types (and purposes) of budgeting used by business are legion. But one distinction that should be drawn by persons analyzing such data is between the use of budgets as forecasting or estimating devices—in a sense akin to scientific forecasting—and the use of budgets as instruments of control and coordination. As Hart has reminded us, uncertainty introduces elements into the picture that cannot be resolved by reference to certainty equivalents of uncertainty. One of these elements is the need, in planning, to plan for replanning as events materialize.

Illustrative of this difference in types are the so-called "variable" (or flexible) and "forecast" (or fixed) budgets. Firms using modern budgetary techniques usually choose the former type for their operating budgets, and the latter for their capital budgets. The two are quite different in emphasis, and hence the figures contained in them need to be interpreted differently. A variable budget is a frank recognition of the low probability to be attached to point, as against interval, estimates. It begins by attempting to secure a "best" estimate of, say, sales, cost of sales, etc., but then immediately begins to prepare for deviations from these values. It may be roughly characterized in the following fashion: "If sales are at 100 per cent of the assumed levels then costs should be of such and such a magnitude, but if sales are only 90 per cent of the assumed levels then costs should be of such and such different magnitude," and so on. The emphasis of the flexible, as compared with the forecast, type of budget is thus on control and coordination. If asked to report a single figure of expected or budgeted sales, costs, etc., business firms using this type of budget for operating purposes and those using a fixed or forecast type of budget are likely to attach quite different meanings to this figure.

As has already been noted, the forecast type of budget is generally used for capital expenditures, and, indeed, it is difficult to see how a flexible budget, strictly interpreted, can be used for these purposes. Thus data on capital expenditures, such as those being exploited by Friend and Bronfenbrenner, are likely to be more homogeneous, at least in this respect, than budgetary data covering operating costs. Of course, this is not to say that budgetary data on capital expenditures can be taken at face value. Even in the case of forecast budgets various trigger criteria at critical stages of execution—such as review by a budgetary committee before work orders are issued—are frequently carefully built into the budget or surrounding budgetary procedures. As Katona has noted, much more in the way of interviewing work, of the kind that Friend and Bronfenbrenner have now begun, is needed before safe ground can be reached in prediction analyses resting on these types of data. Certainly, no mere questionnaire classification into types of budget from which the data are extracted will prove sufficient, since even so-called forecast, or fixed operating, budgets may have strong coordinating and control (corrective or adjustive), as well as forecasting, procedures built into them.

Of some interest in this connection is the use of servomechanism analogies by Modigliani and Sauerlender. These analogies have had a strong appeal to us in work being done at the Carnegie Institute of Technology in connection with a project on intra-firm behavior sponsored by the Air Force. One reason for this appeal is the strong intermixture of control and prediction (or lack of prediction) considerations in the design of such devices.

Here a page may be borrowed from the electrical engineer in his design, say, of a radio. He knows that an undesirable quality in reception is noise or static. He knows that from time to time static will be received, but he does not know when this will occur, or the form it will take. But knowing (or predicting) that it will occur within certain limits, he can build control devices into the mechanism so that these undesirable properties will, within reasonable limits of time and magnitude, be eliminated from the reception.

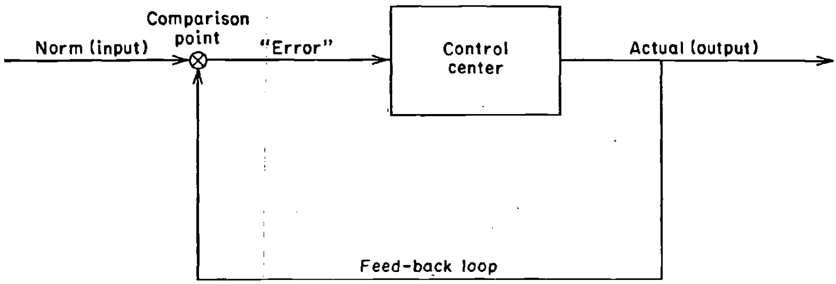
The basic control process built into such devices is not prediction in the usual sense of that term. It is, rather, a process of continuous correction. The elements of prediction involved are: (1) assessment and statement of goals, (2) recognition that disturbances will occur in the process of attaining these goals, and (3) design (prediction of the properties) of a control system or apparatus that will correct for these disturbances when they occur.

Information is gathered at frequent intervals to determine departures of actual behavior from some norm. The difference between the actual and the norm is regarded as an "error," and corrections are made in order to reduce this "error." Diagram 1 illustrates what is involved. A common example of such a servomechanism is the house thermostat, which does not try to predict the weather, but simply measures deviations of actual from desired room temperature and makes appropriate corrections.

No implication that engineering analogies can or should be imported literally into economics is intended. But the central notion of the servomechanism—that behavior in the face of uncertainty can take the form primarily of adjustment rather than prediction—is certainly suggestive for many areas of business behavior.

As a matter of fact there is no reason why adjustment and prediction cannot be combined, why the servomechanism cannot encompass both "feed-back" (or adjustive) and "feed-forward" (or predictive) control. Indeed, Modigliani and Sauerlender have implicitly recognized this by introducing a feed-forward device in their model of production and inventory behavior. For their model

Diagram 1



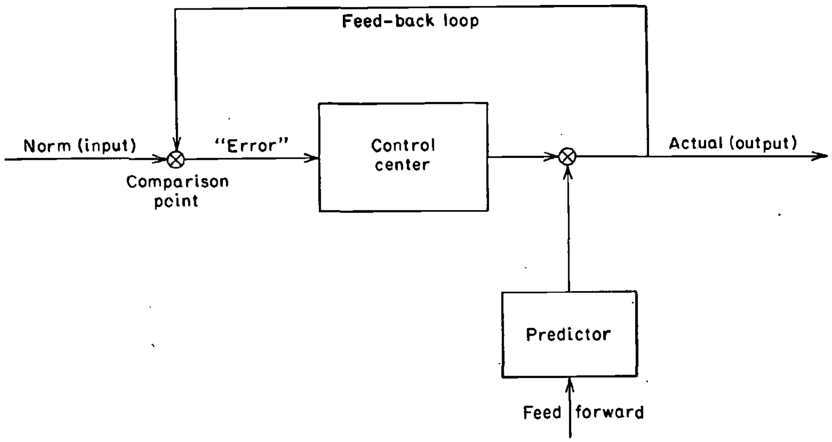
may be pictured as follows: At the present time, t, an estimate is formed of how conditions will appear τ units hence. On the basis of this expectation, and by means of comparison with current outputs, corrective information is carried back to be translated into a change in production or input schedules. A simple pictorial representation of a control system embodying both feed-back and feed-forward is given in diagram 2.[4]

Our investigations have indicated that the introduction of a predictive, feed-forward element into the control system can lead quite easily to unstable behavior in the form of "hunting"—cycles of increasing amplitude—unless the response to the prediction is a highly damped one.

[4] This diagram is drawn from Herbert A. Simon, "On the Application of Servomechanism Theory in the Study of Production Control," *Econometrica*, Vol. 20 (April 1952), pp. 247-268. The use of servomechanisms is suggested in intra-firm analysis by rather strong analogies with the types of administrative control devices and decision rules that are found in many business firms. But judging by Modigliani and Sauerlender's success in applying the analogy to industry analysis, the usefulness of this device is by no means restricted to cases where strong formal administrative apparatuses are present.

Servomechanism analogies, with the precautions noted above, should thus provide a useful tool for the study of control systems. Judging from Modigliani and Sauerlender's application to an important segment of the cement industry, such analogies can be successfully applied even in areas where articulate control systems (such as those commonly found on the intra-firm level) are not present in any formal and developed sense.

Diagram 2



Servomechanical analogies have an additional appeal in suggesting a useful distinction between what might be called "rational" behavior and "adaptive" behavior. The traditional model of economic man has been that of a being who continually strives to attain optimal positions. The behavior of such a creature might be termed "rational." Servomechanism theory suggests, however, the model of an organism that continually adjusts its behavior so that it gets along "well enough"—it adjusts to changes in external conditions rapidly enough and successfully enough to avoid trouble, but it does not in any precise sense maximize or optimize.

Now human behavior probably exhibits elements of both the "rational" and the "adaptive." The notion of adapting to change may well suggest a more realistic model of human behavior in the face of uncertainty than any such sophisticated concept as "maximization of discounted expected gain." If any optimizing principle is involved in the process of adaptation, it is more akin to a "minimax" principle than to a maximum principle. The adaptive system seeks to assure adjustment to the future *whatever it may be*, rather than optimal adjustment to a future that is predicted and described in terms of probability distributions. Even the concept of minimax probably attributes to the adjustive mechanism a more precise criterion of optimality than is generally justifiable.[5]

In any actual organism or organization the effectiveness of adjustment is restricted by, among other factors, limits on the complexity of the problems the system can handle and the cost of securing information. Traditional approaches tend to ignore these costs, or impossibilities, of behaving rationally rather than adaptively. The notion that behavior is necessarily a mixture of the rational and the adaptive suggests the possibility of rephrasing the question of optimality—of asking what is the optimal combination of rational and adaptive behavior rules that should be designed into the system. The advantages to be gained from eliminating or reducing errors can thus be matched against the cost of securing this greater precision—in much the same spirit as this is done in modern theories of sampling.

Even if a model like that employed by Modigliani and Sauerlender is judged to be satisfactory in its handling of uncertainty, it is hard to see how the model deals with mistakes—bona fide mistakes having nothing to do with uncertainty. It would seem preferable to rest models of business and individual behavior on the assumption that mistakes will repeatedly be made and that they will be followed by corrective action looking toward the reduction of undesirable consequences. Again, the mechanism that is suggested is a combination of "adaptive" and "rational" behavior.

One further assumption in this paper should be questioned. This is the assumption, implicitly made, that the system whose behavior is to be predicted is a "given." Now when adaptive behavior must take place in the face of uncertainty, one direction in which optimality can be sought is by reducing the uncertainty—not by gaining

[5] Closely associated with these types of behavior is the distinction between "smooth" and "sudden" adjustments. In complex organisms, including man, mechanisms exist for rational and adaptive adjustment; but also means exist for detecting when the usual adjustment mechanism is inappropriate and for bringing about sudden jumps from one mechanism to another, more appropriate one. A crude example is the behavior of a businessman when he suddenly becomes aware that he is involved in a price war or when, his business having increased rapidly, his working capital position suddenly becomes an acute problem. As Modigliani and Sauerlender note, the use of switching devices by means of which the entire behavioral properties of the system may be changed offers possibilities in this direction.

additional information, but by simplifying and stabilizing the system about which information needs to be obtained. An engineering analogy will illustrate the point. Humidity is an important variable in the spinning room of a textile mill. It would be possible to introduce instruments to measure the humidity and continually adjust the machinery to allow for it; but this is not done in modern installations. Instead a relatively uniform humidity is maintained in the room to avoid the necessity for such adjustment.

Many examples can be found in business behavior of adaptation to uncertainty by removing or reducing its sources. The desire often evidenced by oligopolistic firms to maintain a constant share of the market may fall under this head. The costs associated with adjustment to unpredicted or unpredictable variation in sales may be so great that, even from a profit standpoint, it is preferable to seek certainty in sales volume by tacit agreement as to market shares. The drive toward product differentiation and the aversion to price competition in oligopolistic situations may be based, at least partly, on the same motivations.

All of these complications emphasize, as was mentioned at the outset of these comments, that the study of business forecasts, plans, and expectations must take into account the purposes that the prediction mechanisms serve, and the role that they play (in relation to the other mechanisms) in the total process of adjustment to uncertainty and change.

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If you look at the literature of theoretical dynamics, you will find a fairly clear-cut separation between expectational dynamics and mechanical dynamics. In mechanical models, which predominate, the *events* of past periods enter the equations that determine the events of future periods. In expectational models the corresponding relationships carry *expectations* of past periods.

The mechanical model may of course rest on an expectational theory. Notably in Lawrence Klein's *Economic Fluctuations* do we find preliminary operations with equations in which anticipations figure. But these equations are of such a structure that presently we carry out a substitution, and the result is a set of equations in which only events appear explicitly, and which can be "fitted" to the record of events without requiring any data on anticipations. But note the implications about the formation of anticipations: they must be derived from events endogenous to the model, on a pattern that is either invariant or at most very smoothly changing.

Many of our best mathematical economists are uninterested in expectational dynamics because they object to any system that will not "yield cyclical fluctuations." If we take initial anticipations (like initial stocks of equipment) into our model as "data," we cannot progress far. For stocks of equipment the course of events yields a path of change, so that we can specify events of the first period and set up this part of our data for the second period. But to set up anticipations for the second period is another matter. The utopian solution is to find a comprehensive anticipation-forming equation (which may involve widening the coverage of economists to take in, say, the influence of events on economic journalism) and derive the anticipations as well as the stock of equipment for each successive period. But unless we are prepared to postulate economic determinism for all the phenomena that may influence anticipations—including wars, elections, rise of political leaders, and the like—we may find our model does not work.

This is scarcely a reason for resting content with mechanical models. If in fact expectations carry heavy weight, and if in fact they are heavily influenced by events economists must treat as exogenous, mechanical models will prove misleading as images of prolonged economic sequences.

My impression is that for concrete forecasting we shall be best off with models that take initial expectations as data, and incorporate a rough theory of how expectations respond to surprises. The maximum reach of these forecasts will be hard to gauge until we know more about anticipations and their revision, but presumably it is of the order of one to two years—longer in some contexts than in others.

We also need models of economic fluctuations to exhibit the meaning of our theories of economic interdependence, to forecast the differential effect on fluctuations of alternative policies, and (as a means to the foregoing) to interpret the past in relation to our theories. For this purpose recent developments suggest a hybrid between mechanical and expectational dynamics.

More and more, we find ourselves setting up mechanical models that contain "switching formulas." Some of the equations in our system have substitutes; and we work with a rule that tells us in some circumstances to suppress equation 11 and use instead the alternative equation 11a. The suggestion made earlier in the Conference for including a government-reaction equation is an example of this logic. So long as economic events do not stir up the government, equations that assume (for example) constant tax rates apply. But if unemployment or inflation passes a certain threshold, these equations will no longer apply, and we may be able to introduce a substitute set. Another example of this logic is the substitution of "exogenous" values for various durable goods in the transition models of 1945-1946; still another, the Hicksian "ceiling."

For guidance in setting up both the alternative equations and the switching rules, the study of business forecasting and decision-making will probably prove crucial. This should mean gains for our theories, our differential forecasts of policy results, and our concrete forecasts for the near future.