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SALES AND INVESTMENT:
BEHAVIOR OF MANUFACTURERS
1949-1957

Presented to the Department
of Economics, Oberlin College,
December 16, 1960

by

James G. Scoville

Since the appearance of Keynes' General Theory, the major point of macro-economic emphasis has been upon the conditions and inducements necessary for capital investment. The general view on the dynamic processes of the economy has been largely altered in this past quarter century. No longer do we believe that what is saved automatically finds its way into investment, with total demand---and, hence, income---remaining constant. The Great Depression, the development of fairly decent time series, and the often biting words of Keynes have given business cycle theory a new outlook and a new direction. I do not propose to discuss all these facts in this short paper; the consideration of the classical views and the examination of the ideas of Keynes and his successors can well be left to the reader. Instead, our attention shall be focussed on a very limited aspect of the problem of capital investment, namely, the plant and equipment expenditures of manufacturers during a short period of time. An attempt will be made to go beyond the simple statistical analysis to discover other factors operative in this period, and their possible effects upon our results.

I

The figures and series used in this paper are largely the product of the Office of Business Economics, Department of Commerce, and are taken from the "Survey of Current Business" and its Supplements. The means used to obtain these statistics are varied, and sometimes not entirely reputable. Those employed the most in this paper are estimates of manufacturers' plant and equipment expenditures and sales, the realized figures and the anticipations for both these catagories, as given at the beginning of each year.

These figures are usually reported in either the March or April "Survey."

The limitations of these data should be understood before they are put to use; indeed, the weaknesses are legion. The original figures are obtained by written reports from various manufacturers, which reports are made voluntarily except for approximately one thousand large corporations required to report to the Securities and Exchange Commission. Among the smaller firms, the tendency is not to report if they have spent nothing---this has led to a sample which is stratified in a distinctly top-heavy manner, although corrections have been made for this. Furthermore, it is hardly an exaggeration to conclude that no two persons who fill out the questionnaire have the same idea of the information desired. For the purposes of this paper, however, the most disturbing matter is that the Department of Commerce is not concerned with what manufacturers actually expect, but with predicting what will really happen. Therefore, there is a constant juggling of the figures on the basis of past experience, which makes their data of more value as forecasts, but which represents a caveat to the writer of this paper. Anticipations are reported in the "Survey" with such precise expressions as: 'somewhat over eight percent,' 'about four percent,' and so on. The anticipations figures which I have used are calculated on the basis of the most reasonable reading of such statements.

On the assets side of the balance sheet, there are several factors which recommend these data. Only aggregate figures for manufacturing shall be used, which gives us the hope that the errors of the constituent categories will have cancelled one another. A fact that betokens the absence of some possible 'corrections' is that these figures are not made to fit into the breakdown of investment given in the gross national product accounts. Although it must be said that the most appealing feature of these statistics is their availability, they should be sound enough if used cautiously.

II

It is a simple theoretical connection between consumption, investment, and the "multiplier" which demonstrates the power of changes in investment over the whole economic system. Thereafter, the basic problem has continually presented itself: what are the reasons for fluctuations in the level of investment? In this paper, we shall primarily be looking at that which Keynes called the "principle of effective demand," as it is involved with the manufacturing sector in the years 1949-1957. It must be remembered that there is not an automatic and mechanical link between changes in the effective demand (as represented by the sales of the firms involved) and the decision to invest. The final decision probably rests on a much more poorly defined concept, that of "expectations," upon which sales behavior should have an impact. At times in the statistical development of the argument, it may seem that emphasis is being laid only upon the factor of demand, but, hopefully, other considerations will receive their due at a later point. It should be observed that the two categories denoted above, demand and expectations, cannot be strictly separate areas of consideration, even in the statistical sections. Although the data employed are in constant dollars, which eliminates some of the effects of price changes of product and capital goods, it certainly would not eliminate the effects of anticipated changes. There can be no thorough-going segregation between demand and expectations.

For the most part, the data used cover the period 1949-1957, although there are some exceptions. The price figures employed to reduce sales and expenditures to constant dollars were obtained from the most recent source, U. S. Income and Output, 1958. This is the reason for the cut-off date of 1957. The price figures for plant and equipment of Wooden and Wasson (presented in the November, 1956 "Survey") were not used as they covered even a shorter period and were, in general, close to the figures for producers' durable equipment. Some series presented begin in 1950, as figures from 1949 were needed to determine various values (as in the discussion of the derivation of anticipations). The starting date for this study (1949) is rather arbitrary, but it was felt wise not to push the coverage further back: the references in the "Survey" become even more vague, there were certain convulsions in the population of the sample shortly before the period covered, and thus we avoid most of the immediate effects of the war.

At this time, a brief explanation of the symbols employed may prove of value to the reader. The letters I and S shall refer to plant and equipment expenditures and sales, respectively. When standing alone, they will denote realized quantities, the subscript referring to the year. When these letters are adjoined by a star (*), they will refer to anticipated quantities. The letter F will sometimes be used to designate a computed quantity or a large collection of symbols. To dispel any fears, I will assure the reader that the mathematics in this paper will be simple and largely concealed in the body of the work.

Another point must be made: this paper does not attempt to present a model describing the operations of the manufacturing sector during the years

1949-1957, into which one can plug the data and receive the proper answer. The statistical work is only an attempt to deduce various propositions concerning the behavior of manufacturing with regard to capital investment. Nor does this paper attempt to explain or depict the course of action of any particular firm under given conditions; its conclusions apply only to the collective actions of manufacturers.

III

We might assume that manufacturers as a group would have their investment programs ("investment" is used, unless specifically stated otherwise, to mean "gross investment") closely tied to their sales, as the demand operative upon them affects directly the amount they produce. If demand increases, and inventories are to remain the same, then investment should increase sufficiently to meet the rise in demand, and there should be a reverse effect if demand falls. Nevertheless, in view of inventory and order considerations, we might not have expected the extremely close relation which we find in the data. Expressed in billions of constant (1954) dollars,[1] the linear regression for the years 1949-1957 (see figure 1 on page 6) can be expressed thus:

$$I_n = .638S_n - 3.4 \quad .$$

While it is not correct to place heavy emphasis on a generalized regression figure such as this, the sample ~~regression~~ correlation coefficient (.944) is very significant---we should expect such a result by chance about one time in a million. Thus, our first proposition must be that in this period manufacturers achieved a firm relationship between annual investment and sales.

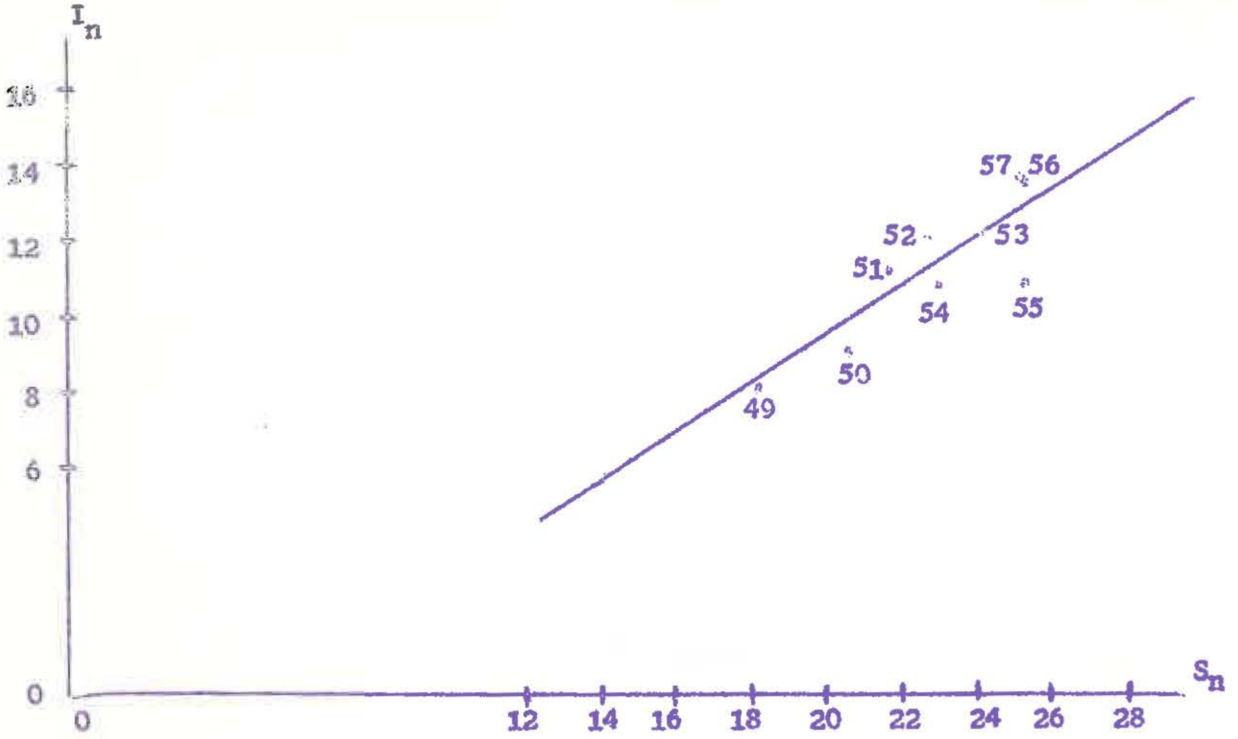

Figure 1.
Investment and Sales in 1954 Dollars.

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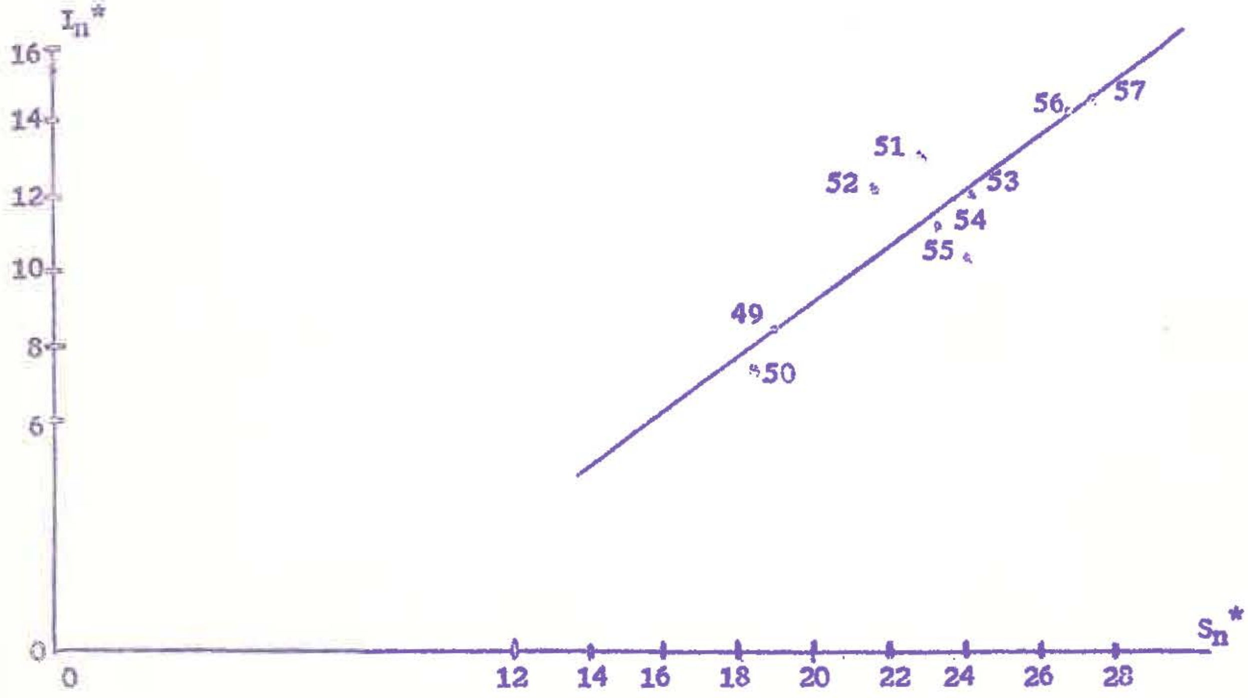

Figure 2.
Anticipated Investment and Sales in 1954 Dollars.

In regard to anticipated investment and anticipated sales, the same type of relationship holds true. For the same period, in billions of constant dollars,[2] the relationship states that: (cf. figure 2, page 6)

$$I_n^* = .736S_n^* - 5.6 \quad .$$

Again the sample correlation coefficient (.816) is significantly high for thirteen degrees of freedom, with approximately the previous probability of chance occurrence, so we deduce proposition two: during this period, manufacturers anticipated a firm relationship between annual investment and sales.

IV

Several matters come to mind from an inspection of these relationships, all of which have implications for economic theory. In the first place, we notice that these equations are not the same---that is to say, the relation of sales to investment and the relation of anticipated sales to anticipated investment are not described by the same line. If sales should have turned out as anticipated, then investment would have differed from the anticipated figure. The difference of relationships implies that, whatever happened, some part of the plans of manufacturers could not be borne out in the resultant year.[3] The direct consequence of this is a corollary that, as it existed during this period, the manufacturing sector of the economy was inherently unstable---in view of the relation between investment and sales uniformly achieved, the anticipated relationship had to fail. Perhaps we can discover the reason for this by a closer look at the relationships themselves. In general, the level of anticipated investment was more closely tied to anticipated sales than was investment tied to sales. This is reflected in the fact that the coefficient is larger in the former relation, .736 versus .638. This difference means that above a certain level of sales (about twenty-two billion constant dollars), the amount anticipated would exceed the actual investment, and below this level anticipations would be less than what resulted. The key to the solution of this presumptuous "paradox" is the fact that what we are calling here "investment" is really gross investment---it includes expenditures for replacement as well as expansion. Thus, it would seem that above the $22 billion level of sales manufacturers have faultily estimated their expenditures by tying them too closely to sales; they have tended to prorate above the level where expansion began on the basis of their replacement expenditures per dollar of sales below that level. Below this level, they perhaps assumed that they would cut back expenditures at the same rate as they would have increased them in expansion, forgetting that the major part of their expenditures would be for replacement. If this were the case, then we would expect that manufacturers would have followed this course of action: to anticipate less investment below a certain level of sales than that which would be justified in the light of figure 1, and to "over-anticipate" above this level. The following table indicates the results of this assumption.

Year	S_n^*	I_n^*	F (I which would be justified on the basis of S_n^*)	Comment
	(Billions of 1954 dollars)			
1949	19.4	8.7	9.0	As these sales figures are below the $22 billion level, we should have expected F greater than I_n^*.
1950	18.9	7.7	8.6	
1951	23.3	13.4	11.4	Conversely, we should have expected I_n^* greater than F.
1952	23.1	12.5	11.3	

Year	S_n^*	I_n^*	F	Comment
1953 1954 1955	24.7 23.9 24.5	12.3 11.5 10.7	12.3 11.8 12.2	As sales were above the $22 billion level, we might have expected that I_n^* would be greater than F, but the reverse was true. Perhaps in 1953 and 1954 investment was anticipated at less than the long-term proper amount, in order to reduce the excess capacity aquired during the Korean War. In 1955, where the only large deviation occurred, it perhaps reflects the intention to fill part of S_n^* by a continuation of the inventory disinvestment begun in 1954.
1956 1957	27.3 28.0	14.6 15.0	14.0 14.4	The result again conforms to our hypothesis, as in 1951 and 1952.

It should be noted that the table shows agreement with the theoretical interpretation of the relationships in six of nine years covered, and a borderline case in 1953, with disagreement arising only in the years 1954 and 1955. The three troublesome years occur when the Korean War was ended (or about to be ended: we remember that one of Eisenhower's pledges in 1952 was to end that war), which undoubtedly would have a dampering effect on expectations. This and the subsequent "readjustment"---as we are wont to euphemize nowadays---should have led us a priori to expect any variations to have occurred in this period.

Thus, from the propositions brought forward in section III, concerning the relation of investment to sales anticipated and that achieved, an attempt has been made to present a theoretical explanation of the difference between the two equations. It has also been indicated that we may see in the proposed explanation a reason for the inherent instability which arises from the difference between the two relationships. This explanation, i. e., that manufacturers anticipated either more or less than they would really need (as measured by past, presumably satisfactory, achievement) on the basis of faulty extrapolations, is based on an assumption that manufacturers have poor methods of estimating future capital needs. This we might readily deduce from a quick glance at figure 2, where we see that the anticipated figures are more dispersed than the corresponding points in figure 1; the guesses of future requirements were more varied than the actual requirements themselves. In a study of 175 large stockmarket firms, Brockie and Grey found that "methods of investment programming are still fairly crude in most firms, with programs being closely dependent upon (a) judgement, and (b) performance in the present and immediate past."[4] If such a judgement can be levied against a fairly select group of large firms, how much more crude may be the methods of smaller firms---the type predominant in the "Survey" sample!

V

Having observed a probable source of error in the anticipations of manufacturers, it is time to take a longer look at the possible derivation of these anticipations. In the first case, let us consider the estimation of anticipated sales, for on what is said here will be based some subsequent assumptions. We assume that the sales of the present year are a substantial factor, and that these figures are known by manufacturers during the time when they anticipate the amounts for the next year. Hence, manufacturers would extrapolate on the basis of this year's esults in order to anticipate next year's sales. A means for understanding the extrapolation to be presented is found in a loose interpretation of the difference between long-term and short-term expectations. It will be assumed that long-term expectations are governed by a comparison of this year's sales with those of last year, while short-term expectations are affected simply by this year's results in comparison with what was anticipated. Thus, we have two distinct "rates of growth:" S_n/S_{n-1}, governing long-term anticipations, S_n/S_n^*, applying to the short term, and both of these are to operate upon S_n to yield the anticipated sales, S_{n+1}^*. It is natural to expect the operation of either rate singly upon S_n to be of a multiplicative nature, and it is assumed that the two rates operate similarly upon one another. This latter process finds its justification in (a) its simplicity---it is not proper to describe the crude process of anticipations outlined in section IV by means of complex equations; and (b) it is reasonable to presume that short-term expectations should interact with those for the long term.

wordy

The result of all these assumptions is the expectation that $S_{n+1}^* \propto Sn \cdot S_n/S_{n-1} \cdot S_n/S_n^*$, or that $S_{n+1}^* \propto S_n^3/S_{n-1}S_n^*$. For the period covering anticipated sales from 1950 to 1959, this relation is found:

$$S_{n+1}^* = .587\frac{Sn^3}{S_{n-1}S_n^*} + 10.1 \;.$$[5]

The correlation coefficient for the sample (.712) is significantly high for the number of degrees of freedom (15) involved. This does not mean that the above assumptions are "true," but rather that they give a fairly close description of the situation, which implies that the assumptions are at least tenable. It is this last statement toward which this analysis was directed, to affirm the reasonableness of the assumptions before proceeding further.

Having determined that the preceding assumptions are at least not unreasonable, we shall now apply them to the question of anticipated investment. With the propositions presented in section III as background, we should feel fairly safe in applying the "two-fold rate of growth" of sales argued above to the question of capital programs. Thus, we should presume that, in some amount, plans will be affected by a term stating that $I_{n+1}^{*} \propto S_n^2 I_n / S_{n-1} S_n^{*}$. The only change from the previous formulation has been the introduction of the I_n term in place of the third S_n. This is not entirely necessary for, as we have seen in section III, there was a direct relationship between sales and expenditures, both realized and anticipated. The forthcoming relationship could have been set up without the I_n term, but for the sake of mathematical simplicity and for a closer approximation to the decision-makers' methods, which most likely include investment of the present year as a factor, the form has been altered.

We now introduce another assumption, one which is hardly disputable in view of the volumes written about it and the theories founded thereon. A variant of the "overinvestment" hypothesis shall be included as a factor involved in the planning of capital investment. As has been discussed in section IV, there must arise a discrepancy between the actual result and the anticipated sales or expenditures or both. An adjustment shall therefore be included for the difference between actual plant and equipment expenditures for a given year, and that which the year's sales results would presumably have justified on the basis of anticipations. If, for any year, manufacturers had in mind a figure for capital investment (the anticipated figure) which they felt would be justified at the anticipated level of sales, then we should expect them to have a feeling of either "overinvestment" or "underinvestment," depending on the relation of actual sales and expenditures to the former anticipations. All this verbal confusion can be conveniently summarized in a simple symbolic expression for the adjustment we should expect them to make:

$$\text{"Discrepancy Adjustment"} = \left[I_n - \frac{S_n}{S_n^*} I_n^* \right].^6$$

This adjustment would be subtracted from the figure obtained by simple investment/sales relation predictions, expressing the final derivation in the form:

$$I_{n+1}^* \propto \frac{S_n^2 I_n}{S_{n-1} S_n^*} - \left[I_n - \frac{S_n}{S_n^*} I_n^* \right]$$

A linear regression for the period 1950-1959, expressed in billions of current dollars, gives this expression, where F stands for the whole right side of the above proportion: (cf. figure 3, below)

$$I_{n+1}^* = .769F + 2.8 \quad .$$

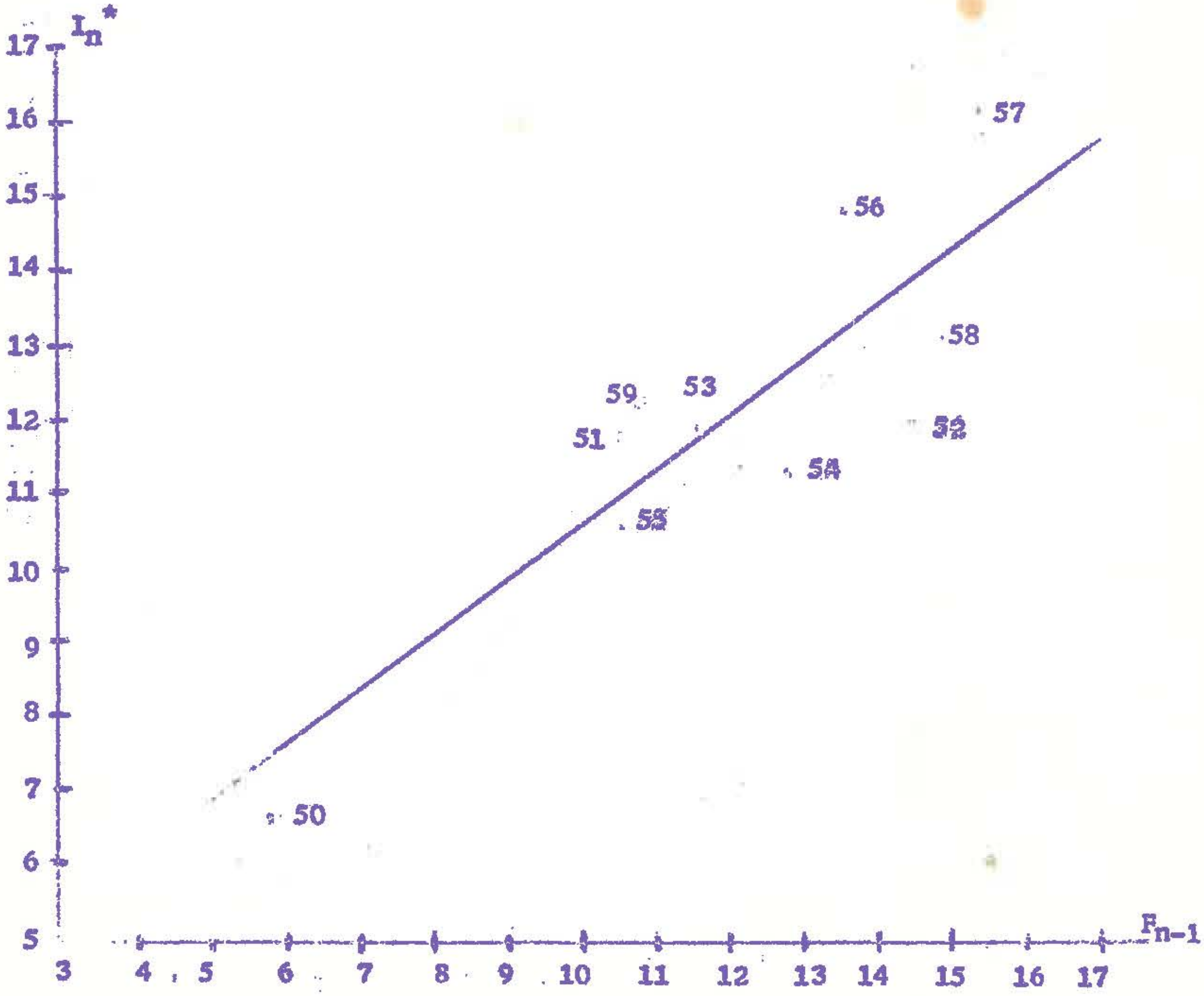

Figure 3.
Anticipated Investment and the proposed function.

This is a pleasing result for two reasons, the first of which is that the sample correlation coefficient (.865) is highly significant for this number of degrees of freedom (15). In the second place, the coefficient of the variable F is much higher than in the former relation concerning sales (.769 versus .587). This means that the values of the independent variable (F here, $S_n^3/S_{n-1}S_n^*$ in the former case) are much more decisive in determining the values of the result I_{n+1}^*, than in determining S_{n+1}^*. This may imply that the investment anticipation relationship is closer to the true process of anticipations determination than was the relatively more mechanical model concerning sales.

This section may be summarized by presenting a proposition that, during this period, investment, after an allowance for adjustment considering the previous year's experience, was planned largely on the basis of anticipated sales. We have seen that a mechanical interpretation of the interaction between long-run and short-run expectations has succeeded as an assumption, as it has produced relationships which amply describe the data on anticipated sales and investment.

VI

The most striking result of the foregoing sections is the fact that investment anticipations and realizations can, in general, be satisfactorily described in terms of past and present sales. The factor of inventory change has not been included as either a stimulant or a depressant on anticipations, and we have arrived at a general picture in which this factor does not seem to be necessary. This is not to assert that inventories are not or were not a real factor in business movement---Metzler has built up a theory of short-term fluctuations founded on changes in inventories---but that, at first sight, it seems strange to be able to describe this period without specific reference to them.

However, a second inspection indicates that in those years when inventory accumulation bore a fairly regular relation to the level of sales, inventory anticipations were already hidden in the figures for the relationship between anticipated investment and sales. The point is made most clearly by looking at the years in figure 2 which are not virtually upon the regression line. 1951 and 1952 stand out as years in which anticipated expenditures were higher than we should have expected from the general performance, with 1955 and (to a lesser degree) 1950 showing the reverse relationship. Both of the former years are those which were preceded by years of high accumulation of inventories: in 1950 inventories rose by $5.5 billion (19.0%), in 1951 by $8.5 billion (24.6%). On the other hand, 1950 and 1955 were preceded by years of inventory disinvestment: -$2.8 billion (-8.8%) in 1949, and -$2.4 billion (-5.2%) in 1954. The anticipated expenditures for 1957 show no difference from the long-run regression, even though inventories rose $5.9 billion (12.7%) in 1956.

The implication of all this is that if the inventory expansion might be expected to continue (sales in both 1950 and 1951 having exceeded the amounts anticipated), then manufacturers planned to spend more on capital than they would have, based on pure sales expectations. 1956 sales did not meet expectations, therefore greater than normal inventory accumulation was not planned for 1957, and hence the point for 1957 appears near the regression line. Similarly, concerning expected outlays for 1950 and 1955, the inventory disinvestment of 1949 and 1954 coupled with the fact that sales declined more than anticipated perhaps led manufacturers to expect a further decline in inventories and, hence, less investment than would normally have been planned. This explanation does not conflict with the traditional theory of the effects of the changes in inventories on investment, and is apparently only a development of the notion of a "fixed" sales/inventories ratio. However, as a matter of fact there is little direct confrontation between the two explanations: Metzler's theory is based on a sudden, unexpected change in inventories and its immediate effect on plans. The above explanation covers longer periods of time in which the question of lags other than one year (as is general throughout this paper) has disappeared, and plans are made on the basis of trends which manufacturers may or may not wish to continue. Basing this reasoning about the deviations from the long-term trend of figure 2 on inventories seems to be reasonable, as deviations occurred only for those years before which there had been a sharp change in the trend of inventories.

VII

It is apparent at a glance that an attempt to explain the deviations about the trend of figure 1 will have to include more factors than inventory change. The deviations are smaller, but there are many more of them although the trend is more representative of the data than in figure 2, the correlation coefficient being .944 here and .816 in figure 2). It will be less confusing to present if the matter is considered not by sections devoted to the application of a particular factor to each year, but by bringing forward the possible factors, year by year. Less attention will be paid to specific relations here, as the deviations are quite small.

I do not choose to split hairs over small variations based on data of questionable precision---instead, a general view of the possible modifying factors will be presented.

1949---The variation was negligible.

1950---The fact that investment was below the amount expected from the long-run relation was not due to purely economic factors, but rather to the outbreak of the Korean War. As a result, sales rose very sharply, but there was apparently not enough of the year left to show the reaction of investment.

1951-1952---Investment was higher than the long-term relation, probably in major part due to the continuance of the war, and in an attempt to compensate for the "underinvestment" of 1950.

1953---The variation was negligible: despite a substantial drop in unfilled orders, new orders remained steady, and actual sales were almost indentical with those anticipated.

1954---Capital outlays were below the amount expected for the level of sales, but part of the sales were filled by inventory disinvestment. This exercised a depressing influence on the level of expenditures as sales were declining, unfilled orders still falling. A situation of excess capacity had developed after the relatively high investment years of 1951 and 1952.

1955---Manufacturers were hesitant in emerging from the recession, raising their outlays only slightly in the face of increased sales, new orders and backlog. A partial cause of their caution may have been the fact that the prices of their sales had risen by 2.6% since 1953, but the price level of producers' durables had increased by 3.6%.

1956-1957---The continued boom in 1956 drew more than normal expenditures to compensate for the low level of 1955, and in both years to assist the building up of inventories. Sales prices increased very sharply in these two years (7.3%), the sharpest rise during this period 1949-1957, which presumably would have provided an inducement to invest, even though prices of producers' durables continued their upward march.

VIII

In figure 1, investment was related to sales; in figure 2, anticipated investment was related to anticipated sales. Then in section V, anticipated investment was related to an adjusted rate of growth of sales, the result of which was seen in figure 3. Using much the same method as employed in section VI, we shall now investigate the variations about the trend found in this latter correlation. Considering the *a priori* nature of the assumptions made in section V, small variations are of even less significance as the basis for such a relation is not as obvious as for figures 1 and 2. It is more obvious to assume a direct relationship between capital outlays and sales for a specific year (either actual or anticipated), than to assume that a fairly arbitrary mathematical model describes the actual process of decision. Hence, in an attempt to evaluate the influence of other factors, only large variations from the regression line will be considered.

As figure 3 is drawn in current dollars, it might be apparent that some of the variations from the trend will be due to price movements. Thus, for example, in 1949 the prices of capital goods rose 5%, but prices of sales dropped 2%; as we should suppose, this combination was not conducive to capital anticipation: 1950 appears below the trend line. Similar reasoning applies to 1954 anticipations based on a rise of capital prices greater than the rise of sales prices in 1953. Nevertheless, an attempt to explain the variations on the basis of price changes alone must fail; an orderly pattern of the type just indicated simply does not appear. 1957 anticipations are above the regression line, although producers' durables rose in price by 6% in 1956, while sales prices rose only 4½%. This does not deny that prices had an effect, but rather implies that the effects were not orderly nor probably large: we should seek the major reasons elsewhere. A similar argument could be presented to justify the omission from consideration of that neo-classical keystone, interest rates. I will simply note that Duesenberry has found little effect of interest rates (once one gets the matter quantified) on investment, due in part to the much larger factor of taxes on profits.[7]

It may be observed that the years 1951 and 1956 are above the trend line in figure 3, whereas the preceding years 1950 and 1955 were below the trend depicted in figure 1. This would imply that attempts were being made to counteract the relatively low investment of the preceding years. Similarly, the anticipations for 1952 and 1958 are below the regression, perhaps in attempts to remedy the "overinvestment" occurring in 1951 and 1957. Furthermore, with the exception of 1952, the same inventory argument advanced in section VI seems to be applicable. If it had been justified in the minds of manufactuers to continue a process of rapid accumulation, then we should expect investment anticipations to be inordinately high, and lower if a continued inventory disinvestment might be expected.

Thus, the general conclusion of this section (applying also to sections VI and VII) is that, in the period 1949-1957, manufacturers' investment-sales relations followed fairly defined patterns. Deviations around these trends can largely be attributed to the movements of inventories and orders, with a consideration of the effects of the Korean War. The factors of smaller movement (prices and interest rates) seem to have had no measurable effects, and were overshadowed by larger and more powerful factors.

IX

> There is, however, little evidence to support the theory that expectations are self-fulfilling.
>
> The view of the future held by important decision makers only partly influences their decisions. And their decisions only partly determine the outcome. Many things happen that nobody decides, wants, or expects.
> ---V. Lewis Bassie [8]

Heretofore, the discussion has dwelt upon first the relation of investment to sales, then that of anticipated investment to anticipated sales. We have noted that the difference between the two relationships was sufficient to guarantee a difference between expectattions and realizations. What, we should now like to know, occurred when sales differed from their anticipated level? At this point we might hope to gain an insight into the dynamics of manufacturers' reactions to the real course of events.

A regression was derived for the period 1949-1957 (see figure 4, below) which gave this relation (in constant dollars):

$$I_n = .874 I_n^* \left(\frac{S_n}{S_n^*}\right) + 1.4 \quad .$$

The sample ~~regression~~ correlation coefficient was approximately 1.0, a very unlikely occurrence by pure chance at 13 degrees of freedom. The fact that this hypothesis is representative of the data can easily been seen from figure 4. Only the point for the year 1951 is relatively distant from the regression line, and this deviation we must attribute to the supply situation which developed as a result of the outbreak of war.[9] Our faith in this relation is further substantiated when a similar relationship, expressed in current dollars is offered as evidence: its sample correlation coefficient was .961 at 17 degrees of freedom. This relationship is the link between the two equations presented in section III, and relates them to the variations from expectations encountered in each year. It contains further evidence for the $22 billion "median" level of sales mentioned frequently before. If sales turn out as expected (i.e., $S_n/S_n^* = 1$), then investment will be greater than anticipated below sales of $22 billion, and less than anticipated above that level. The general hypothesis of

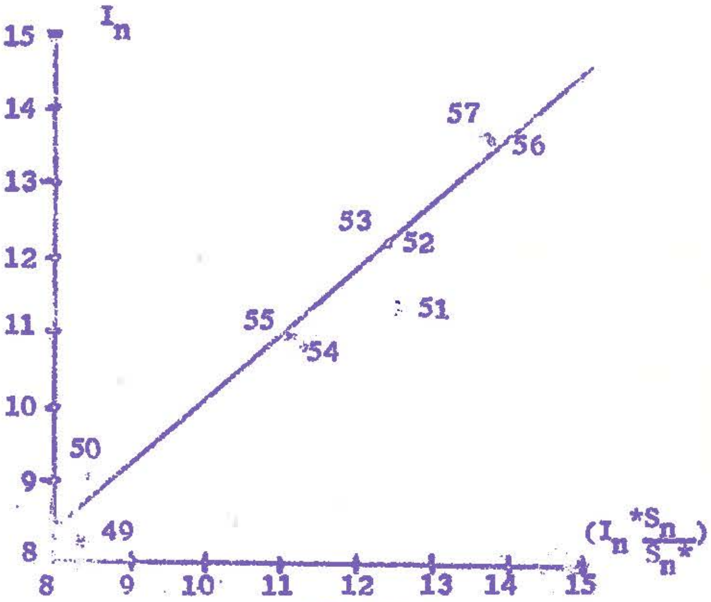

Figure 4.
Changes of investment and sales *versus* anticipations.

this paper, that investment in manufacturing was principally based on effective demand, is strongly supported by this relationship, excluding as it does all other factors. We conclude that manufacturers responded quickly (within the same year) to the developments of the year in progress, and their reactions were based upon a comparison between actual developments and anticipations regarding sales.

Friend and Bronfenbrenner, in their survey study, came to the opposite conclusion about the effect of sales on capital outlays.[10] They surveyed 305 large firms whose 1949 expenditures had differed from anticipations by twenty-five percent or more, and found a strong positive correlation only for those firms which specified sales as the major factor involved in the change. Nevertheless, almost all of the factors which they enumerated involved an outlook on sales: certainly a firm's sales experience affects its desire to switch to newer equipment or its opinion of the capital goods market. Their study can actually have little connection with this paper---their study covered only a small select group of firms. A firm which deviated twenty-five percent from its anticipations could well find other reasons than sales to specify, without denying their effect. This paper has looked only at the aggregate behavior of the group, and must consider the opinions of individual manufacturers as merely "interesting."

X

In this thesis, manufacturing has largely been dealt with as an atomistic, self-contained unit within the economy. This is, of course, an extreme oversimplification: demand changes from the rest of the economy have an effect on the level of demand within the manufacturing sector. Manufacturers produce the major part of all the plant and equipment covered by the data, excluding taxes and non-materials costs included in the value of plant and equipment. Expecting to find some evidence of an "acceleration principle," a regression between sales and investment (the converse of that done in section III) has the form

$$S_n = 1.16I_n + 10.1 \quad ,$$

and a significant sample correlation coefficient of .785. Expressed in English, manufacturers' sales consisted of approximately the amount spent by the group for investment plus a constant $10.1 billion. It is interesting to note that the sum of the constant and the average level of investment ($11.5 billion) approximates the $22 billion level of sales which has played such a lerge part in the previous considerations. Without a lengthy and involved analysis, it is sufficient to observe that the division of sales between durable and non-durable goods generally follows the proportions indicated by the regression. We should have expected that investment would be less than, but nearly a constant proportion of, durable goods sales, while sales of non-durables should approximate the constant, being largely sales to the rest of the economy. Further breakdowns, both by durable _versus_ non-durable goods manufacturers and by size of firm, would shed even more light upon the internal processes of the manufacturing sector. Such examinations will, however, be left to future writers of theses, when more data will hopefully be available.

The above considerations, giving a general idea of the internal relations of the manufacturing sector, combine with the previous discussions of the relationships between investment and effective demand to further demonstrate the potency of the demand factor. As we have seen, investment (both realized and anticipated) is closely related to the level of (actual or anticipated) sales. Manufacturers, subject to the provisos of section I, seem to adjust their investment levels to the developments of the year in progress. Capital outlays for the succeeding year can be interpreted to include an adjustment for "over-" or "underinvestment" based on the present year's performance. The acceleration involved in the fact that that which is one firm's investment is another firm's sales concludes our investigation of the hypothesis of "effective demand." Subsidiary factors and non-economic developments can account for the deviations about the regressions, but the main point is clear--- in this period, manufacturers' investment behavior was dependent upon the level and changes of demand.

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NOTES

1. Adjusted on the basis of indices found in U. S. Income and Output, 1958: investment by the price level of producers' durable goods and sales by the level of prices of all wholesale commodities excluding food.

2. Adjusted by the same indices as in note 1, but using the prices of the year in which the anticipations were made to deflate them.

3. That is, unless by chance S_n and S_n^* were equal at 22.

4. M. D. Brockie and A. L. Grey, jr., "The Marginal Efficiency of Capital and Investment Programming," "Economic Journal," December 1956, p. 675.

5. Expressed in current dollars, in order not to exclude possible interaction between changes in price levels.

6. If this adjustment were set up with more sophistication, as we earlier noted that manufacturers anticipated faulty relations between investment and sales, the subsequent relationship might even provide a closer fit to the data.

7. James S. Duesenberry, Business Cycles and Economic Growth, (McGraw-Hill, New York, 1958), pp. 49ff.

8. National Bureau of Economic Research, Recent Developments in Short-Term Forecasting, (New York, 1955), pp. 10-11.

9. See the "Survey of Current Business," February 1952, especially its review of the year 1951, and also the "Survey" for September 1951, pp. 5-7.

10. Friend and Bronfenbrenner, "Plant and Equipment Programs," in Recent Developments in Short-Term Economic Forecasting, NBER.

APPENDIX I

CRITICAL VALUES OF THE CORRELATION COEFFICIENT

Degrees of Freedom	.05 Probability	.01
12	.532	.661
13	.514	.641
14	.497	.623
15	.482	.606
16	.468	.590
17	.456	.575
18	.444	.561

Courtesy of Professor Wade Ellis.

RELATIONSHIPS PRESENTED IN THIS PAPER, WITH THEIR DEGREES OF FREEDOM, AND SAMPLE CORRELATION COEFFICIENTS (r).

$I_n^* = .736S_n^* - 5.6$ 13 d.f. $r = .816$

$I_n = .638S_n - 3.4$ 13 d.f. $r = .944$

$S_{n+1}^* = .587(S_n^3/S_{n-1}S_n^*) + 10.1$

15 d.f. $r = .712$

$$I_{n+1}^* = .769\left[\frac{S_n^2 I_n}{S_{n-1}S_n^*} - \left(I_n - \frac{S_n}{S_n^*}I_n^*\right)\right] + 2.8$$

15 d.f. $r = .865$

$I_n = .874\ I_n^*(S_n/S_n^*) + 1.4$

13 d.f. $r \doteq 1.0$

$I_n = .930\ I_n^*(S_n/S_n^*) + .7$ (current dollars)

17 d.f. $r = .961$

$S_n = 1.16I_n + 10.1$ 13 d.f. $r = .785$

APPENDIX II

MANUFACTURERS' SALES AND INVESTMENT (CURRENT DOLLARS)

Year	Sales	Anticipated Sales	Plant and Equipment	Ant. P&E
1948	$17.6 (billion)		$8.3 (billion)	
1949	16.4	17.5	7.2	7.2
1950	19.3	16.7	8.2	6.7
1951	22.3	21.4	11.1	11.9
1952	22.8	23.4	12.0	12.1
1953	24.5	24.4	12.3	12.0
1954	23.5	23.8	11.0	11.4
1955	26.3	24.5	11.4	10.7
1956	27.7	27.9	15.0	15.0
1957	28.4	29.9	16.0	16.4
1958	26.2	27.8	11.4	13.2
1959	29.6	28.6	12.1	12.3

Source:"Survey of Current Business,"
1949-1960

APPENDIX III

PRICE INDICES

Year	Wholesale: all commercial excluding food.	Producers' Durable Equipment.
	(1954 = 100)	
1948	90.3	83.1
1949	88.5	87.0
1950	91.7	89.0
1951	101.2	96.8
1952	98.9	97.5
1953	99.6	99.0
1954	100.0	100.0
1955	102.2	102.6
1956	106.7	109.0
1957	109.7	115.8
Sources:	Adapted from data in September, 1958 "Survey."	*U.S. Income and Output, 1958,* p. 221.

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FIRST REGRESSIONS IN AN OC ECONOMICS HONORS THESIS?

James G. Scoville, A.B. mcl 1961, A.M., Ph.D. January 8, 2016

To the best of my knowledge, the attached senior honors thesis, *Sales and Investment: Behavior of Manufacturers, 1949-57,* represents the first use of regression analysis in such papers. If it was the first, its story is more than a little odd and unusual. I shared some of this with Hirsch Kasper who suggested I write it up to accompany my personal copy of the thesis to some resting place in the Library.

The summer after my junior year, I worked in the Business Structures Division of the US Department of Commerce. My duties focused on the quarterly Survey of Plant and Equipment Expenditures, especially the most boring and mundane: verifying the handwritten entries on master sheets for each company against the original paper surveys and entering numbers for purchases of used equipment which had not been recorded before. There was a roomful of career clericals doing the same thing and I inadvertently became a "ratebuster," since I wasn't used to pacing myself as they were. Some hostility surfaced, but I got the message and spent hours watching the fish in the "National Aquarium," which was in the basement of the Commerce building.

At some point, my job got enriched and I was asked to do a regression or two and given a sheet of paper entitled "Simplex method for one or two variables." This I copied on a sheet of Thermofax paper (if you know that stuff, you are definitely old enough to be reading this), which I took to Oberlin with me in the fall. The data for the regressions came from the *Survey of Current Business* and other government publications.

Armed with data and Thermofaxed instructions, I was ready for the next step, actually doing the regressions. The College did not have (at least available to students) either of the then popular mechanical calculating machines (Frieden or Marchant). The pinnacle of quantitative sophistication was located in the Government Department where answers to survey questions could be entered on large sheets of paper with holes corresponding to potentially interesting "cuts" of the sample (e.g., by gender), the sheets placed in a box with corresponding holes so that when a dowel was inserted through the box, you could simply lift out all the sheets corresponding to a variable of interest (e.g., females).

This was of no use to me: regression was the way. Thus, I calculated the various cross-products on a slide rule (see parenthetical comment above on Thermofax paper), added them up with paper and pencil, and back to the slide rule for division problems. The rest, as they tritely say, is history.

But there's a little more that needs to be said: on page 11 a singularly awful sentence has been underlined and awarded the epithet "woolly" by my dad, Orlin J. Scoville. "Joe" Scoville also earned a Ph. D. in economics at Harvard. So far as I know, he and I are the only father-son pairing to share a committee member , John T. Dunlop.

In 1960, there were (I think) ten of us in the honors seminar. You wrote the paper during fall semester and then presented it in the spring. Ken Roose was my advisor; I ran into him in the lobby of Carnegie shortly before Christmas break and asked if he wanted to see the paper before I turned it in. He said it would be customary or conventional, I don't remember which. Finally, it is interesting that the 1956 edition of *Webster's New Collegiate Dictionary* (which I have used all my life) does not contain the statistical definition of "regression"! I guess my thesis was really ahead of its time.