# Expense or Capitalize R&D – SFAS 2 Revisited

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**Abstract**

FASB's Statement of Financial Accounting Standard No. 2 requires that most of the expenditures incurred in Research and Development Activity be expensed in the period incurred. Expensing a long term asset understates assets and understates true income for a firm in the period, and if R&D activity is material then the users of financial statements are misled into making non-optimal decisions regarding investment and lending to such firms. This paper presents arguments for recording of R&D expenditures as creation of an asset and suggests time periods over which this asset may be amortized. Cross-lagged panel technique is used to infer the direction of causality.

**Keywords:** Research and Development, causality, cross-lagged panel

## 1. Introduction

The Financial Accounting Standards Board's (FASB) Statement of Financial Accounting Standard No. 2 (SFAS 2) requires that most research and development expenditures (R&D) incurred by firms be expensed in the period incurred. One of the principal reasons offered by FASB for this requirement was the relatively high level of uncertainty surrounding future benefits from such expenditures. A secondary reason was the (alleged) lack of demonstrated causal relationship between expenditures and benefits. According to FASB, prior empirical studies had "generally failed to find a significant correlation between R&D expenditures and increased future benefits as measured by subsequent sales, earnings or share of industry sales" (FASB 1974, p. 16). Although FASB offered additional reasons for its position, the requirement to expense R&D is based primarily on this lack of demonstrated causality (Bierman and Dukes, 1975).

The purpose of this study is to test for the presence and the direction of causality between R&D and sales. The method employed is well-suited for this task: the cross-lagged panel analysis. Possible amortization periods for R&D are also estimated and presented.

FASB's position regarding expensing of R&D is contrary to the basic definition of an asset – anything that provides benefit to the firm in the future. Prima facie, why would a firm spend any money on R&D unless it expects to receive a benefit in the future? The existing treatment to not capitalize R&D understates assets and understates income for the firm in the periods of any material R&D activity. Further, the recognition of In-process R&D upon acquisition of another entity results in an inconsistency, since similar R&D projects at the acquiring firm are not recognized. Comparability is also compromised when an acquiring firm with material In-process R&D is analyzed against a firm that has significant ongoing R&D projects. Expensing an asset with long-term benefits is also an obvious violation of the matching principle, and application of the conservatism principle is not an entirely winning argument.

R&D activity, driven by the global nature of today's economy and technological advances have a very significant impact on the firms and the financial markets (Bracker and Ramaya, 2011). First 150 years of the U.S. history, the total expenditure on research was approximately $18 billion (Priest, 1966) compared to an estimated $452 billion in just 2012 (NSF Report, 2013). Analysis of financial statements and other such information does not match up with the value of the firm as pegged by the Stock Market due to a variety of reasons. One reason that is cited often is the limitation of financial statements due to the recognition criteria to remain in accordance with GAAP. An important example is the non-recognition of R&D in the balance sheet (Hershey and Weygandt, 1985). A study of the impact of R&D on Tobin's Q found that there exists a curvilinear with a diminishing marginal benefit of R&D intensity (Bracker, Ramaya, 2011).

Besides reporting issues, a more significant effect, however, could be the impact of this rule on managerial behavior. Prakash and Rappaport argue that imposed accounting changes may affect management decisions through the process of 'information inductance'. This concept implies that management may alter its behavior due to the expected impact of financial reporting on users of that information. R&D expenditures directly flow through the income statement and this could make management believe that investors and/or creditors may change their expectations about the firms future cash flows, with consequences for both credit and investment decisions. Another impact could result from the way in which many management compensation packages are structured. If management compensation is tied to accounting net income, then there may be incentives to reduce R&D expenditures due simply to the requirement to expense such costs. Soon after SFAS 2, Horowitz and Kolodny presented evidence indicating that small, high technology firms reduced R&D spending in response to

this pronouncement. Another study by Vigeland of larger firms found no market reaction to SFAS 2, implying that investors did not expect a change in management behavior. These contradictory results may be due to sample selection, but indicate at least the potential presence of information inductance.

FASB has devoted a considerable effort in developing and expanding its Conceptual Framework. An explicit objective was to provide FASB with a theoretical framework useful as a basis for formulating and evaluating accounting standards. Statement of Financial Accounting Concepts No. 1 (SFAC 1) for example, states that the primary focus of financial reporting is to disseminate information about an enterprise's performance, provided by measures of earnings and its components (FASB, 1978, para. 43). The statement goes on to assert that accrual accounting provides these measures better than information about current cash receipts and payments. It is interesting to note that SFAS 2, issued prior to SFAC 1 emphasizes current cash payments as the required approach for dealing with R&D, contrary to the position taken by the FASB in SFAC 1.

Another part of the Conceptual Framework discusses elements of financial statements. FASB's definition of an asset in this statement is of particular relevance to this study. According to SFAC 2, a non-cash resource must satisfy three conditions to qualify as an asset. First, the resource must contribute directly or indirectly to future cash inflows. Secondly, the enterprise must be able to obtain benefits from it. Finally, the transaction or event leading to the future benefit must already have occurred. Of particular relevance to this study is the first condition, namely, the connection between current expenditures and future benefits. Internal consistency of accounting rules is a very desirable quality to strive for. Consistent application of standards, if nothing else, may increase users' confidence in, and understanding of published financial statements. If, for example, it can be shown that R&D clearly produces future benefits, then there exists little justification in treating R&D differently from any other created/constructed or acquired asset. The issue of future benefits is, of course, an empirical question, and this the objective of this study. The period immediately following the promulgation of SFAS 2 is analysed in this study.

## 2. Research Design

Cross-lagged panel analysis is a techniquethat inferscausality by comparing cross-lagged correlations between two or more variables measured at two or more points in time. The method attempts to assess whether one variable at time t influences another variable at a later time, say t+1. Anderson and Kida (1982) have provided a detailed description of the technique and its possible application in accounting. The purpose of this section is to briefly outline its adaptation to the topic at hand.

Let us assume that we have measurements on two panel variables, Research and Development expenditures (R), and Sales (S), at two points in time. These variables may be designated as follows:

R1 = value of R at time 1
R2 = value of R at time 2
S1 = value of S at time 1
S2 = value of S at time 2

Let us further assume that we wish to determine whether R1 influences S2, or whether S1influencesR2. Our model would look like this:
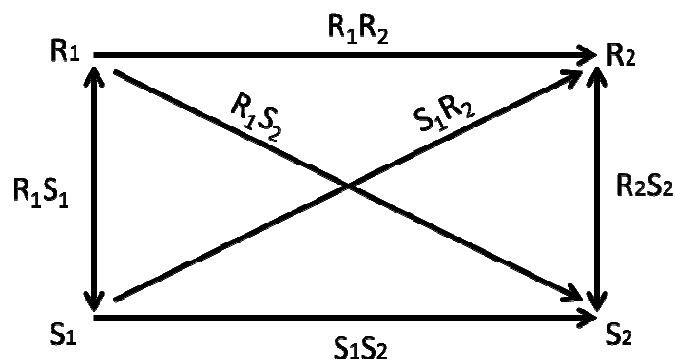


Figure 1. Cross Lagged-Panel Model

One way to answer this question would be to compare the two cross lag correlations, R1S2 and S1R2. If R1S2 > S1R2, we would infer that the preponderant direction of causality was from R1 to S2. If S1R2 > R1S2, then the inference is that the direction of causality is from sales in period 1 to R&D in period 2. The task, however, is more complex that this simplistic procedure would suggest.

Three conditions must be satisfied before the cross-lagged panel technique can be successfully applied to infer the direction of causality. First, synchronicity must be evident or demonstrable. Synchronicity in this context

means that the two panel variables being evaluated are measured at the same pointin time. Generally, aggregation of the values of a variable or their averaging over time poses a synchronicity problem. In the case of sales and R&D, the measurement of these variables continuously throughout a given accounting period ensures the simultaneity of their measurement. Thus, synchronicity is not problem in this application of cross-lagged panel technique.

A second condition that must be satisfied is stationarity. Stationarity is the presumption that the causal processes did not change during the interval measured. There are three different types of stationarity, according to Kenny (1975). Perfect stationarity means that there is no change in the structural equations over time. This implies the equality of the synchronous correlations of the variables at the two pointsin time at which they are measured. Proportional stationarity means that the structural equations change over time by the same constant. Quasi-stationarirty is defined by Kenny as the case where the causal coefficients of each variable change by a proportional constant, but each variable has its own unique constant. This implies that the synchronous correlations would be equal if corrected for the attenuation due to measurement error. For this study, a hypothesis of perfect stationarity could not be rejected for all lags and industry groups.

A third condition required for inferring causality from cross-lagged panel analysis is stability. Stability implies that the autocorrelations for the two variables respectively are equal. Rogos (1980) has shown that a cross-lagged panel analysis can be misleading when there are causal effects but one of the variables is more stable than the other. The technique will pick the less stable variable as the time-dominant factor. For this study, as shown in the Findings section   below, null hypothesis of equal autocorrelations could not be rejected in all cases.

Finally, it is worthwhile to note that Fisher's Z-transformation cannot be used to test for significance of the differences in correlations (i.e. the synchronous, serial, and cross-lagged correlations) because of their interdependence. Instead, Pearson-Filan Z-statistic is used. The square of this Z-statistic is distributed as a chi-square with one degree of freedom (Kenny, 1975). As explained later, advertising expenditures were considered a possible control variable but was determined to be unnecessary, so the uncorrected correlations are the ones reported and interpreted in the results.

## 3. Design and Methodology

The rationale for comparing R&D to sales is based on the underlying assumption that R&D activities can conceptually affect sales in a cross-sectional context. That is, the differences in R&D expenditures between different firms in the same industry are expected to contribute to differences in sales levels at some future (unspecified) date or dates. For this assumption to hold, the R&D activities engaged in must have the potential to influence future sales.R&D activities engaged in by firms can be grouped into three categories:

1.  Basic R&D activities designed to extend the general scientific knowledge in a particular area;
2.  Applied R&D activities intended to develop new products, or to refine existing products;
3.  Process research which is aimed at developing new, more efficient production techniques or equipment.

Of these three, the last two appear to be the most financially significant types of R&D undertaken by industrial firms. Applied research would, if successful, enable a firm to offer new products or refined existing products. If its competitors do not undertake similar research successfully, they may lose market share to the successful firm or risk survival. Thus, cross-sectionally, successful R&D activities will lead to relatively higher future sales. Success in R&D activities is assumed to be a function of expenditure levels, with higher amounts likely leading to successful outcomes.

Furthermore, it would appear that multiyear commitments as opposed to single year efforts are required to ensure successful outcomes. Thus, data for several years would need to be pooled in order to be able to detect any relationship between R&D expenditures and sales.

An unresolved problem is the specification of the appropriate lead-lag relationship between R&D and sales. Obviously, the lead time required for a multiyear commitment to a particular R&D strategy to yield results is likely to be industry-specific (it may even be firm or project-specific). Thus, the most that can be hoped for is to derive average lead-times for R&D activities for the broad industry groups.

Given the need to pool data across time as discussed above, the effects of inflation have to be dealt with explicitly. Consumer Price Index (CPI) was chosen to deflate both R&D and sales. It is recognized that other possible approaches could have been used, but the wide use of CPI does not pose any serious problems.

The data for this study were extracted from Compustat. Years starting from 1974 to 1984 were chosen to start from the time of SFAS 2 in 1974. First, industries were selected that have shown or were expected to show significant R&D activity. A list of industries is presented in the summary of results presented in Table 2. For each firm, data was obtained regarding net sales, net income before extra-ordinary items, and R&D expenditures. Only firms with positive R&D expenditures in all years and having the data available for all years were included in this study. Four hundred and twenty (420) firms were selected for further study. The data were pooled for reasons given earlier in the scheme depicted in Table 1.

**Table 1**

**Sample Design Scheme for Cross-lagged Analysis**

|       | Pooled for Base Years | Pooled for Lagged Years |
|-------|-----------------------|-------------------------|
| Lag 1 | 1974 - 1983 | 1975 - 1984 |
| Lag 2 | 1974 - 1982 | 1976 - 1984 |
| Lag 3 | 1974 - 1981 | 1977 - 1984 |
| Lag 4 | 1974 - 1980 | 1978 - 1984 |
| Lag 5 | 1974 - 1979 | 1979 - 1984 |
| Lag 6 | 1974 - 1978 | 1980 - 1984 |
| Lag 7 | 1974 - 1977 | 1981 - 1984 |
| Lag 8 | 1974 - 1976 | 1982 - 1984 |

## 4. Findings

As stated earlier, there was no reason to believe that the strength and directionality of the results will be stationary across different industry groups. Consequently, it was decided to carry out the analysis by industry. To provide some perspective on the results obtained, some general statistics on sales, R&D expenditures, and advertising expenditures for the selected period are shown in Tables 2 and 3 below:

**Table 2**

**Selected Statistics for Variables of Interest (1975)**

| Group # | Group Name | Sales (in $ m) | | | R&D (in $ m) | | | Advertising (in $ m) | | | # of Firms |
|---------|------------|------|------|------|------|------|------|------|------|------|-----|
|         |            | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max | |
| 1 | Extractive | 949.40 | 16.20 | 3316.30 | 8.95 | 0.35 | 33.50 | 0.04 | 0.00 | 0.15 | 8 |
| 2 | Agriculture | 967.00 | 93.00 | 3013.30 | 4.94 | 0.39 | 13.46 | 24.85 | 0.00 | 72.05 | 12 |
| 3 | Pulp/Paper | 642.10 | 52.66 | 1940.00 | 13.19 | 0.14 | 88.96 | 9.50 | 0.00 | 24.87 | 10 |
| 4 | Drug/Chemical | 703.22 | 1.31 | 4479.80 | 2223.00 | 0.01 | 208.25 | 25.34 | 0.00 | 215.94 | 76 |
| 5 | Petroleum | 6981.00 | 327.40 | 27831.00 | 31.58 | 4.84 | 116.00 | 3.24 | 2.38 | 4.54 | 13 |
| 6 | Rubber | 637.80 | 7.20 | 3382.00 | 11.52 | 0.18 | 73.00 | 9.14 | 0.00 | 57.52 | 16 |
| 7 | Metal-Wkg | 302.30 | 10.58 | 1780.50 | 3.49 | 0.05 | 21.05 | 11.24 | 0.00 | 115.26 | 20 |
| 8 | Mfg. Mach. | 315.40 | 8.80 | 3079.20 | 6.65 | 0.12 | 74.94 | 2.08 | 0.00 | 20.69 | 51 |
| 9 | Sci/Med Equip | 330.60 | 2.67 | 3076.00 | 16.12 | 0.21 | 194.13 | 7.42 | 0.00 | 78.91 | 29 |
| 10 | Aircraft | 1402.60 | 6.03 | 14894.00 | 36.32 | 0.11 | 463.77 | 12.21 | 0.00 | 137.91 | 15 |
| 11 | Elect. Equip | 864.60 | 4.79 | 8312.10 | 19.29 | 0.10 | 221.53 | 10.16 | 0.00 | 89.21 | 25 |
| 12 | Teleph/graph | 539.30 | 1.47 | 7051.80 | 12.38 | 0.02 | 135.86 | 5.81 | 0.00 | 66.89 | 26 |
| 13 | Electronic. Comp | 107.28 | 6.26 | 848.40 | 5.46 | 0.06 | 31.46 | 1.52 | 0.00 | 13.65 | 17 |
| 14 | Computers | 574.85 | 2.91 | 8955.60 | 34.85 | 0.00 | 586.84 | 1.23 | 0.00 | 11.70 | 28 |

The figures in Table 2 illustrate that among the industries covered, the average proportion of sales devoted to R&D ranged from 0.9 percent for agricultural firms to 6.1 for computer firms in 1975. For 1985, the ranges were from 0.1 percent for agricultural firms to 8.7 percent for electronic components.

It is interesting to note that, in terms of total dollar expenditures the mean R&D expenditures exceeded the expenditures on advertising in 12 out of the 14 industries in both 1975 and 1985. Advertising can influence sales, thus, higher expenditures for advertising for some industries suggests that controlling for its influence may be important in the cross-lagged panel analysis. Advertising expense was chosen as a possible control variable in the analysis.

**Table 3**

**Selected Statistics for Variables of Interest (1985)**

| Group # | Group Name | Sales (in $ m) | | | R&D (in $ m) | | | Advertising (in $ m) | | | # of Firms |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max | |
| 1 | Extractive | 1093.70 | 26.56 | 4510.90 | 21.80 | 0.02 | 130.50 | 0.02 | 0.00 | 0.17 | 8 |
| 2 | Agriculture | 989.64 | 134.40 | 3085.70 | 7.78 | 0.70 | 26.66 | 46.33 | 0.00 | 137.09 | 12 |
| 3 | Pulp/Paper | 743.93 | 65.44 | 2435.10 | 22.76 | 0.39 | 157.36 | 7.69 | 0.00 | 28.81 | 10 |
| 4 | Drug/Chemical | 815.20 | 1.96 | 9150.50 | 37.67 | 0.13 | 355.00 | 39.24 | 0.00 | 335.20 | 76 |
| 5 | Petroleum | 8578.80 | 449.70 | 26900.37 | 56.93 | 2.27 | 211.36 | 1.88 | 0.00 | 3.76 | 13 |
| 6 | Rubber | 549.34 | 4.78 | 2974.89 | 13.85 | 0.09 | 92.68 | 9.06 | 0.00 | 63.90 | 16 |
| 7 | Metal-Wkg | 269.30 | 15.49 | 886.03 | 3.38 | 0.02 | 19.99 | 12.57 | 0.00 | 72.61 | 20 |
| 8 | Mfg. Mach. | 275.78 | 5.76 | 2087.20 | 7.89 | 0.04 | 69.14 | 3.39 | 0.00 | 53.32 | 51 |
| 9 | Sci/Med Equip | 398.77 | 13.23 | 3299.50 | 26.63 | 0.22 | 302.92 | 10.35 | 0.00 | 127.56 | 29 |
| 10 | Aircraft | 1052.34 | 4.65 | 16379.40 | 57.64 | 0.17 | 626.32 | 20.69 | 0.00 | 260.58 | 15 |
| 11 | Elect. Equip | 874.45 | 5.74 | 8778.71 | 26.13 | 0.04 | 331.78 | 18.51 | 0.00 | 113.90 | 25 |
| 12 | Teleph/graph | 541.23 | 1.01 | 3684.39 | 33.47 | 0.04 | 336.75 | 4.10 | 0.00 | 44.28 | 26 |
| 13 | Electronic. Comp | 203.85 | 8.43 | 1528.40 | 17.68 | 0.20 | 124.77 | 2.18 | 0.00 | 13.81 | 17 |
| 14 | Computers | 1034.87 | 2.24 | 15532.70 | 78.54 | 0.19 | 1072.94 | 8.24 | 0.00 | 45.93 | 28 |

## 5. Results of Cross-Lagged Analysis

The detailed results of the cross-lagged panel analysis are summarized in Table 4.

The Appendix presentsTables 6 through 10 with the details of the Cross-lagged panel analysis. Each of these tables initially presents the synchronous correlations to indicate the degree of stationarity of the relationship between R&D and sales at different lags. Subsequently, the autocorrelations are presented. It may be recalled that autocorrelations are important in cross-lagged panel analysis because of findings that, given different degrees of autocorrelations, the more unstable variable often appears as the time-dominant or causal factor using this methodology.

It was also mentioned earlier that advertising was to be used as a control variable, if necessary, since advertising expenditures might exert a contemporaneous influence on sales. An examination of the correlations between advertising and the two panel variables (R&D and Sales) shows its effect to be largely insignificant for most lags and for most industry groups. For this reason, the correlations of advertising with the two panel variables are not reported, and the results of cross-lagged panel analysis presented are based on the original rather than partial correlations.

An examination of the cross-lag correlations and their differences presented in table 4 to 9 show the following results:

For industry group 1 (Extractive Industries), the results show R&D as time-dominant over sales. The Z-values calculated are significant for lags 2 through 8. It implies that for the period studied, R&D expenditures for the mining firms in the sample did lead to increases in sales and the impact lasted from 2nd through the 8th year.

For group 2 (Agriculture), the negative sign of the difference in cross lag correlations indicates that sales were time-dominant over R&D for the period studied. Indeed, for all eight lagged periods, the Z-values are statistically significant. The increases in the level of statistical significance though, may be spuriously induced by the decreases in sample size as more and more observations were discarded due to non-availability of complete data necessary for computing higher order lags. An alternative possible interpretation for this finding is suggested by the relatively low average R&D expenditures as compared to sales for firms in this sector. The low R&D/sales proportion observed for this group may be due to the fact that substantial crop and animal husbandry research is conducted by agricultural schools and state cooperative extension services, and thus the firms in the industry are spared major expenditures for this purpose.

The results for industry group 3 (Pulp and Paper) show no significant cross lag correlation differences except at lag 7. The positive sign throughout indicates that R&D is time-dominant over sales but significant only at lag 7. This implies prior R&D levels generally influence future sales for the firms in this sample with average lead time for R&D expenditures to influence sales around 7 years. The same conclusion applies to industry group 4 (Drugs/Chemicals). The significant cross-lagged correlation differences occur at lags 5 through 8. Implying again that R&D was time-dominant over sales, with the average payoff period ranging from 5 to 8 years.

For the remaining industry groups, R&D dominates sales unambiguously for group 6 (Rubber), group 7 (Metal-Working), group 12 (Telephone/Telegraph), and group 14 (Computers). However, there are differences between these industries with respect to the average lag between the R&D expenditures and the discernible effect on sales. These differences are undoubtedly due to the fact that the nature of R&D expenditures is not uniform across

industries, with some undertaking more basic as opposed to applied research.

**Table 4**

**Summary of Results of Cross-Lagged Analysis**
**Presented in Table 5 to 9**

| Industry Group No. | Industry Name | Direction of Time Dominance | Lag(s) at which Cross-Lag Difference Significant |
|---|---|---|---|
| 1 | Extractive | R&D > Sales | Lag 2 to Lag 8 |
| 2 | Agriculture | Sales > R&D | Lag 1 to Lag 8 |
| 3 | Pulp/Paper | R&D > Sales | Lag 7 |
| 4 | Drug/Chemical | R&D > Sales | Lag 5 to Lag 8 |
| 5 | Petroleum | Sales > R&D | Lag 1 to Lag 8 |
| 6 | Rubber | R&D > Sales | Lag 2 to Lag 8 |
| 7 | Metal-Wkg | R&D > Sales | Lag 1 to Lag 5 & Lag 8 |
| 8 | Mfg. Mach. | Sales > R&D | Lag 1 to Lag 8 |
| 9 | Sci/Med Equip | Sales > R&D | Lag 1 to Lag 4 |
| 10 | Aircraft | Mixed Results<br>Sales > R&D<br>R&D > Sales | <br>Lag 1 to Lag 2<br>Lag 7 to Lag 8 |
| 11 | Elect. Equip | Mixed Results<br>Sales > R&D<br>R&D > Sales | <br>Lag 3 to Lag 4<br>Lag 7 to Lag 8 |
| 12 | Teleph/graph | R&D > Sales | Lag1 to Lag 2<br>Lag 6 to Lag 8 |
| 13 | Electronic. Comp | Sales > R&D | Lag1; Lag 4 to Lag 5 |
| 14 | Computers | R&D > Sales | Lag 1 to Lag 8 |

In contrast to the above results, sales are time-dominant over R&D for industry group 8 (manufacturing/Machinery), group 9 (Scientific/Medical Equipment), and group 13 (Electronic Components). Among possible interpretations for this finding, a plausible one is that, in these industries, an affordability criterion is used to determine the amount spent on R&D activities, and whatever effect R&D has on future sales is overwhelmed by the regularity with which the affordability criterion is applied.

Alternatively, these results may indicate that competition is so fierce in these industries that any new products introduced as a result of R&D activities are effectively matched by similar new products by their respectivecompetitors. Obviously, in such a case, no discernible sales advantage will result from new products introduced. A third possible interpretation is that the products are fungible or near-fungible (as in the case of some electronic components) and thus cost-competitiveness rather than product innovation determines changes in market share. Unfortunately, it is impossible to identify which of these three possible reasons accounts for the results found using the techniques and data analyzed here.

A third group of industries display somewhat mixed results. For industry group 10 (Aircraft), and group 11 (Electrical Equipment), sales are time-dominant over R&D in some early lags, but R&D is time-dominant in later lags. A possible interpretation for these seemingly anomalous results is that the firms determine their R&D expenditure levels using the affordability criterion based on earlier years' sales levels. Subsequently, however, these R&D expenditures result in new products which discernibly affect future sales. For the electrical machinery industry, for example, the results show that the average R&D expenditures are determined by sales of the prior three to four years. The average payoff period for R&D, however, is seven to eight years after the expenditures are made. Similarly, for the aircraft industry, R&D expenditures are influenced by sales in the preceding two years. These R&D expenditures on an average result in new products with effect on sales four to seven years into the future.

## 5. Relationship of Time-Dominance to Research Intensity

To determine if the results found from the cross-lagged relationships are related to differences in research intensity as measured by the average R&D/Sales ratios computed for each industry group for 1975 and 1985, we performed a rank order correlational analysis. To convert the cross-lagged correlation differences into rank

orders, the magnitude of the Pearson-Filon Z-statistic was used as a basis for rank-ordering industry groups. In this scheme, positive differences in the cross-lagged correlations (which signified R&D time-dominant over sales) were given positive signs, while negative differences were assigned a negative sign. The resulting rank-ordering is depicted the third column of Table 10.

**Table 5**

**Results of Tests to Determine Relationship Between**
**Research Intensity and Time-Dominance of R&D and Sales**

| Group # | Group Name | 1975 R&D/Sales | | 1985 R&D/Sales | | Time-Dominance | |
|---|---|---|---|---|---|---|---|
| | | Ratio | Rank | Ratio | Rank | Z-Stat | Rank |
| 1 | Extractive | 0.009 | 13 | 0.001 | 14 | +3.82 | 8 |
| 2 | Agriculture | 0.005 | 11 | 0.008 | 12 | -3.69 | 11 |
| 3 | Pulp/Paper | 0.020 | 10 | 0.031 | 10 | +4.35 | 3 |
| 4 | Drug/Chemical | 0.320 | 4 | 0.046 | 9 | +4.12 | 6 |
| 5 | Petroleum | 0.005 | 11 | 0.007 | 1 | -5.22 | 13 |
| 6 | Rubber | 0.015 | 8 | 0.025 | 8 | +3.96 | 7 |
| 7 | Metal-Wkg | 0.012 | 9 | 0.013 | 11 | +4.17 | 5 |
| 8 | Mfg. Mach. | 0.021 | 7 | 0.029 | 7 | -6.03 | 14 |
| 9 | Sci/Med Equip | 0.049 | 3 | 0.067 | 3 | -4.07 | 12 |
| 10 | Aircraft | 0.001 | 14 | 0.035 | 5 | +5.20 | 2 |
| 11 | Elect. Equip | 0.022 | 6 | 0.030 | 6 | -2.20 | 9 |
| 12 | Teleph/graph | 0.023 | 5 | 0.062 | 4 | +4.25 | 4 |
| 13 | Electronic. Comp | 0.051 | 2 | 0.087 | 1 | -2.65 | 10 |
| 14 | Computers | 0.061 | 1 | 0.079 | 2 | +6.48 | 1 |

Kendall's coefficient of concordance
1975 R&D/Sales vs. 1985 R&D/Sales          0.852     (F-ratio = 5.74*)
1975 R&D/Sales vs. Time-Dominance          0.491     (F-ratio = 0.97)
1985 R&D/Sales vs. Time-Dominance          0.602     (F-ratio = 1.51)

* Significant at alpha of less than 0.05

As can be seen in the table above, three evaluations of rank orders were made using Kendall's coefficient of concordance (Kerlinger, 1973 pp. 292-295). The first compared the 1975 and 1985 research intensity measures. The score obtained for Kendall's W is 0.852 with an associated F-ratio of 5.74 which is significant at an alpha of less than 0.05. Thus for the two extreme ranges of the period covered in this study, there was no change in the relative research intensities of the different industry groups.

The next two evaluations compare the 1975 and 1985 research intensity rank orders with the time dominance rank orders respectively. For the comparison with 1975, Kendall's W is 0.49 and the associated F-ratio is 0.97 which indicates that it is insignificant at any reasonable alpha level. Similarly, Kendall's W for the comparison with 1985 is 0.60 with an associated F-ratio of 1.51, which also is insignificant. Thus, one can conclude that the incidence of the time-dominance of R&D expenditures over sales is not related to the relative research intensity, at least for the industry groups and time periods covered in this study.

**6. Conclusions**

The objective of this study was to examine the relationship between R&D expenditures and sales over the period immediately following the issuance of SFAS 2. Previous research had been unable to reach any clear conclusion because the statistical techniques used could not identify the direction of causality. The use of cross-lagged panel analysis allows us to determine the time-dominance of R&D relative to sales.

The general conclusion reached is that for 9 out of 14 industry groups examined, R&D expenditures can be shown to lead to future increases in sales. The lags over which the relationship holds, however, are diverse. Thus, one possible reason why prior research may have failed to identify the relationship may be the specification of an inappropriate lag. For the remaining 5 industry groups, it was found that prior periods' sales had a greater influence on R&D expenditures than vice-versa.

It was also found that, for all industry groups, the strength of the time-dominance of R&D over sales was not related to relative research intensity as measured by the average R&D expenditures to sales ratio. Thus, research intensive industry groups do not necessarily emerge as the ones where higher R&D expenditures lead to discernible sales increases.

Unfortunately, our research design did not permit the identification of reasons that underlie the time dominance

of sales over R&D in the five industry groups where this was the case. Some of the reasons might be:

1. An affordability criterion is used in these industries to determine the general level of R&D expenditures, with sales levels of prior years' used to determine what can be afforded. This criterion is used regardless of the degree of success achieved from R&D activities.

2. Competition may be so fierce in these industries that, to stay up with competition in terms of market share, a fairly constant proportion of sales must be devoted to R&D activities. New products developed from such activities, however, are matched by competitors such that no disproportionate gain in sales occurs from these expenditures.

3. A third possible interpretation is that the products in these industries are fungible or quasi-fungible, and thus R&D expenditures are mostly oriented toward developing cost-saving production techniques rather than new products. Thus, R&D expenditures may lead more to cost reduction and income gains than to direct sales gains.

Further research is needed to determine if any of these possible reasons can explain the phenomenon. Nevertheless, findings that in two-thirds of the industry groups, R&D has a discernible time-dominance over sales suggest that FASB may have erred in rejecting the capitalization of R&D expenditures in favor of immediate expensing in SFAS 2. At the very least, the issue needs to be reexamined for the periods since the time of this pronouncement.

In a forthcoming paper, the author will examine the period following the period of this study to determine changes in management behavior and statistical relationships between variables of interest. Of added interest is the confounding implications of accounting treatment of R&D and In-Process R&D under GAAP, SEC rules, IRS code, and IASB.

## Appendix
### Table 6

### Results of Cross-lagged Panel Analysis for Industry Groups

#### Industry Group 1, Extractive

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.363 | 0.399 | 0.448 | 0.495 | 0.503 | 0.501 | 0.508 | 0.513 |
| | $R_nS_n$ | 0.336 | 0.329 | 0.322 | 0.313 | 0.303 | 0.282 | 0.251 | 0.228 |
| AUTO | $R_0R_n$ | 0.993 | 0.978 | 0.955 | 0.942 | 0.931 | 0.931 | 0.926 | 0.911 |
| | $S_0S_n$ | 0.984 | 0.953 | 0.925 | 0.896 | 0.867 | 0.857 | 0.856 | 0.867 |
| CROSS | $R_0S_n$ | 0.364 | 0.392 | 0.411 | 0.422 | 0.466 | 0.502 | 0.536 | 0.564 |
| | $S_0R_n$ | 0.327 | 0.308 | 0.306 | 0.295 | 0.268 | 0.239 | 0.207 | 0.166 |
| | DIFF. | 0.037 | 0.084 | 0.105 | 0.127 | 0.198 | 0.263 | 0.329 | 0.398 |
| | Z | 1.56 | 1.89* | 1.67* | 1.91* | 2.16* | 2.57* | 2.63* | 3.82* |

#### Industry Group 2, Agriculture

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.822 | 0.811 | 0.796 | 0.774 | 0.732 | 0.653 | 0.620 | 0.594 |
| | $R_nS_n$ | 0.852 | 0.874 | 0.891 | 0.912 | 0.935 | 0.948 | 0.944 | 0.939 |
| AUTO | $R_0R_n$ | 0.964 | 0.896 | 0.836 | 0.775 | 0.704 | 0.616 | 0.586 | 0.566 |
| | $S_0S_n$ | 0.991 | 0.979 | 0.968 | 0.960 | 0.955 | 0.957 | 0.956 | 0.954 |
| CROSS | $R_0S_n$ | 0.800 | 0.766 | 0.727 | 0.685 | 0.637 | 0.577 | 0.549 | 0.530 |
| | $S_0R_n$ | 0.853 | 0.857 | 0.856 | 0.867 | 0.876 | 0.869 | 0.861 | 0.850 |
| | DIFF. | -0.053 | -0.091 | -0.129 | -0.182 | -0.239 | -0.292 | -0.312 | -0.320 |
| | Z | 2.82* | 2.84* | 3.06* | 3.47* | 3.69* | 6.58* | 3.23* | 2.75* |

#### Industry Group 3, Pulp/Paper

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.847 | 0.846 | 0.846 | 0.843 | 0.839 | 0.836 | 0.833 | 0.832 |
| | $R_nS_n$ | 0.846 | 0.847 | 0.851 | 0.855 | 0.861 | 0.865 | 0.869 | 0.866 |
| AUTO | $R_0R_n$ | 0.999 | 0.997 | 0.995 | 0.994 | 0.995 | 0.995 | 0.995 | 0.993 |
| | $S_0S_n$ | 0.996 | 0.989 | 0.982 | 0.978 | 0.977 | 0.977 | 0.977 | 0.973 |
| CROSS | $R_0S_n$ | 0.847 | 0.849 | 0.852 | 0.857 | 0.862 | 0.868 | 0.871 | 0.866 |
| | $S_0R_n$ | 0.845 | 0.841 | 0.839 | 0.837 | 0.835 | 0.833 | 0.829 | 0.827 |
| | DIFF. | 0.002 | 0.008 | 0.013 | 0.020 | 0.027 | 0.035 | 0.042 | 0.039 |
| | Z | 0.33 | 0.70 | 0.57 | 0.95 | 1.26 | 0.72 | 4.35* | .99* |

\* Significant at alpha of less than 0.05

Table 7

Results of Cross-lagged Panel Analysis for Industry Groups

Industry Group 4, Drugs/Chemicals

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.894 | 0.894 | 0.894 | 0.892 | 0.889 | 0.890 | 0.888 | 0.887 |
| | $R_nS_n$ | 0.892 | 0.892 | 0.892 | 0.893 | 0.894 | 0.896 | 0.897 | 0.898 |
| AUTO | $R_0R_n$ | 0.994 | 0.984 | 0.970 | 0.956 | 0.949 | 0.951 | 0.953 | 0.954 |
| | $S_0S_n$ | 0.987 | 0.967 | 0.946 | 0.928 | 0.912 | 0.899 | 0.885 | 0.884 |
| CROSS | $R_0S_n$ | 0.847 | 0.849 | 0.852 | 0.857 | 0.862 | 0.868 | 0.871 | 0.866 |
| | $S_0R_n$ | 0.845 | 0.841 | 0.839 | 0.837 | 0.835 | 0.833 | 0.829 | 0.827 |
| | DIFF. | 0.002 | 0.008 | 0.013 | 0.020 | 0.027 | 0.035 | 0.042 | 0.039 |
| | Z | 1.05 | 0.33 | 0.34 | 1.57 | 2.80* | 3.65* | 4.12* | 4.04* |

Industry Group 5, Petroleum

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.881 | 0.885 | 0.888 | 0.891 | 0.885 | 0.939 | 0.955 | 0.962 |
| | $R_nS_n$ | 0.882 | 0.886 | 0.892 | 0.895 | 0.905 | 0.935 | 0.983 | 0.996 |
| AUTO | $R_0R_n$ | 0.988 | 0.971 | 0.945 | 0.922 | 0.905 | 0.894 | 0.888 | 0.882 |
| | $S_0S_n$ | 0.986 | 0.960 | 0.933 | 0.912 | 0.911 | 0.943 | 0.969 | 0.969 |
| CROSS | $R_0S_n$ | 0.865 | 0.839 | 0.812 | 0.796 | 0.801 | 0.823 | 0.856 | 0.867 |
| | $S_0R_n$ | 0.909 | 0.919 | 0.921 | 0.917 | 0.917 | 0.927 | 0.933 | 0.925 |
| | DIFF. | -0.044 | -0.080 | -0.109 | -0.121 | -0.116 | -0.104 | -0.077 | -0.058 |
| | Z | 3.57* | 3.77* | 3.99* | 3.45 | 3.01* | 3.1* | 5.22* | 3.41* |

Industry Group 6, Rubber

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.916 | 0.917 | 0.921 | 0.927 | 0.929 | 0.930 | 0.930 | 0.930 |
| | $R_nS_n$ | 0.912 | 0.910 | 0.907 | 0.905 | 0.899 | 0.896 | 0.904 | 0.910 |
| AUTO | $R_0R_n$ | 0.992 | 0.985 | 0.975 | 0.967 | 0.962 | 0.961 | 0.967 | 0.969 |
| | $S_0S_n$ | 0.987 | 0.966 | 0.948 | 0.930 | 0.923 | 0.928 | 0.947 | 0.954 |
| CROSS | $R_0S_n$ | 0.897 | 0.881 | 0.961 | 0.849 | 0.843 | 0.848 | 0.868 | 0.875 |
| | $S_0R_n$ | 0.919 | 0.921 | 0.924 | 0.920 | 0.919 | 0.921 | 0.926 | 0.933 |
| | DIFF. | -0.022 | -0.040 | 0.037 | -0.071 | -0.076 | -0.073 | -0.058 | -0.058 |
| | Z | 4.87* | 5.41* | 6.03* | 5.63* | 5.26* | 4.79* | 3.93* | 3.69* |

* Significant at alpha of less than 0.05

Table 8

Results of Cross-lagged Panel Analysis for Industry Groups

Industry Group 7, Metal Working

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|---|---|---|---|---|---|---|---|---|---|
| SYNCH | $R_0S_0$ | 0.876 | 0.882 | 0.877 | 0.854 | 0.805 | 0.821 | 0.835 | 0.824 |
|  | $R_nS_n$ | 0.866 | 0.867 | 0.858 | 0.861 | 0.886 | 0.916 | 0.883 | 0.860 |
| AUTO | $R_0R_n$ | 0.990 | 0.978 | 0.962 | 0.948 | 0.934 | 0.918 | 0.900 | 0.886 |
|  | $S_0S_n$ | 0.990 | 0.970 | 0.944 | 0.920 | 0.909 | 0.909 | 0.919 | 0.925 |
| CROSS | $R_0S_n$ | 0.848 | 0.852 | 0.851 | 0.850 | 0.855 | 0.858 | 0.868 | 0.875 |
|  | $S_0R_n$ | 0.825 | 0.800 | 0.773 | 0.745 | 0.719 | 0.693 | 0.672 | 0.654 |
|  | DIFF. | 0.023 | 0.052 | 0.078 | 0.105 | 0.136 | 0.165 | 0.196 | 0.221 |
|  | Z | 3.41* | 4.05* | 4.17* | 3.84* | 2.75* | 1.45 | 0.76 | 2.67* |

Industry Group 8, Manufacturing Machinery

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|---|---|---|---|---|---|---|---|---|---|
| SYNCH | $R_0S_0$ | 0.916 | 0.917 | 0.921 | 0.927 | 0.929 | 0.930 | 0.930 | 0.930 |
|  | $R_nS_n$ | 0.912 | 0.910 | 0.907 | 0.905 | 0.899 | 0.896 | 0.904 | 0.910 |
| AUTO | $R_0R_n$ | 0.992 | 0.985 | 0.975 | 0.967 | 0.962 | 0.961 | 0.967 | 0.969 |
|  | $S_0S_n$ | 0.987 | 0.966 | 0.948 | 0.930 | 0.923 | 0.928 | 0.947 | 0.954 |
| CROSS | $R_0S_n$ | 0.897 | 0.881 | 0.961 | 0.849 | 0.843 | 0.848 | 0.868 | 0.875 |
|  | $S_0R_n$ | 0.919 | 0.921 | 0.924 | 0.920 | 0.919 | 0.921 | 0.926 | 0.933 |
|  | DIFF. | -0.022 | -0.040 | 0.037 | -0.071 | -0.076 | -0.073 | -0.058 | -0.058 |
|  | Z | 4.87* | 5.41* | 6.03* | 5.63* | 5.26* | 4.79* | 3.93* | 3.69* |

Industry Group 9, Scientific/Medical Equipment

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|---|---|---|---|---|---|---|---|---|---|
| SYNCH | $R_0S_0$ | 0.977 | 0.980 | 0.981 | 0.980 | 0.979 | 0.976 | 0.975 | 0.976 |
|  | $R_nS_n$ | 0.971 | 0.971 | 0.971 | 0.974 | 0.976 | 0.980 | 0.981 | 0.979 |
| AUTO | $R_0R_n$ | 0.998 | 0.996 | 0.994 | 0.992 | 0.991 | 0.990 | 0.991 | 0.991 |
|  | $S_0S_n$ | 0.997 | 0.992 | 0.984 | 0.979 | 0.979 | 0.983 | 0.988 | 0.992 |
| CROSS | $R_0S_n$ | 0.968 | 0.965 | 0.961 | 0.962 | 0.966 | 0.968 | 0.970 | 0.965 |
|  | $S_0R_n$ | 0.973 | 0.977 | 0.980 | 0.978 | 0.977 | 0.975 | 0.977 | 0.979 |
|  | DIFF. | -0.005 | -0.012 | -0.019 | -0.016 | -0.011 | -0.007 | -0.007 | -0.014 |
|  | Z | 3.19* | 3.79* | 4.07* | 2.57* | 0.63 | 0.84 | 0.83 | 0.49 |

* Significant at alpha of less than 0.05

Table 9

Results of Cross-lagged Panel Analysis for Industry Groups

Industry Group 10, Aircraft

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.941 | 0.937 | 0.934 | 0.935 | 0.938 | 0.945 | 0.945 | 0.936 |
| | $R_nS_n$ | 0.949 | 0.954 | 0.959 | 0.961 | 0.957 | 0.957 | 0.961 | 0.970 |
| AUTO | $R_0R_n$ | 0.989 | 0.968 | 0.945 | 0.932 | 0.936 | 0.942 | 0.954 | 0.963 |
| | $S_0S_n$ | 0.986 | 0.958 | 0.934 | 0.931 | 0.944 | 0.957 | 0.961 | 0.960 |
| CROSS | $R_0S_n$ | 0.930 | 0.914 | 0.911 | 0.925 | 0.954 | 0.965 | 0.969 | 0.967 |
| | $S_0R_n$ | 0.952 | 0.938 | 0.915 | 0.896 | 0.888 | 0.887 | 0.890 | 0.893 |
| | DIFF. | -0.022 | -0.024 | -0.004 | 0.029 | 0.066 | 0.078 | 0.079 | 0.074 |
| | Z | 4.32* | 3.17* | 0.95 | 2.12* | 4.88* | 5.20* | 4.77* | 3.93* |

Industry Group 11, Electrical Equipment

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.985 | 0.988 | 0.991 | 0.991 | 0.991 | 0.993 | 0.993 | 0.993 |
| | $R_nS_n$ | 0.982 | 0.983 | 0.983 | 0.981 | 0.984 | 0.984 | 0.984 | 0.985 |
| AUTO | $R_0R_n$ | 0.997 | 0.994 | 0.993 | 0.994 | 0.994 | 0.995 | 0.996 | 0.993 |
| | $S_0S_n$ | 0.998 | 0.996 | 0.993 | 0.991 | 0.991 | 0.991 | 0.994 | 0.994 |
| CROSS | $R_0S_n$ | 0.981 | 0.981 | 0.980 | 0.978 | 0.980 | 0.983 | 0.989 | 0.990 |
| | $S_0R_n$ | 0.983 | 0.984 | 0.984 | 0.984 | 0.984 | 0.985 | 0.985 | 0.981 |
| | DIFF. | -0.002 | -0.003 | -0.004 | -0.006 | -0.004 | -0.002 | 0.004 | 0.009 |
| | Z | 1.56 | 1.31 | 1.79 | 2.20* | 1.41 | 0.41 | 1.87 | 2.70* |

Industry Group 12, Telephone/Telegraph

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|------|-----|------|------|------|------|------|------|------|------|
| SYNCH | $R_0S_0$ | 0.908 | 0.921 | 0.934 | 0.940 | 0.944 | 0.945 | 0.946 | 0.944 |
| | $R_nS_n$ | 0.858 | 0.859 | 0.862 | 0.860 | 0.861 | 0.863 | 0.871 | 0.878 |
| AUTO | $R_0R_n$ | 0.970 | 0.968 | 0.957 | 0.948 | 0.952 | 0.952 | 0.954 | 0.940 |
| | $S_0S_n$ | 0.995 | 0.983 | 0.967 | 0.952 | 0.942 | 0.940 | 0.937 | 0.928 |
| CROSS | $R_0S_n$ | 0.898 | 0.895 | 0.890 | 0.884 | 0.884 | 0.898 | 0.914 | 0.927 |
| | $S_0R_n$ | 0.961 | 0.864 | 0.867 | 0.864 | 0.866 | 0.858 | 0.849 | 0.837 |
| | DIFF. | -0.063 | 0.031 | 0.023 | 0.020 | 0.018 | 0.040 | 0.065 | 0.090 |
| | Z | 4.28* | 2.75* | 1.47 | 1.08 | 0.86 | 1.85 | 2.66* | 2.96* |

* Significant at alpha of less than 0.05

Table 10

Results of Cross-lagged Panel Analysis for Industry Groups

Industry Group 13, Electronic Components

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|---|---|---|---|---|---|---|---|---|---|
| SYNCH | $R_0S_0$ | 0.939 | 0.934 | 0.933 | 0.933 | 0.935 | 0.934 | 0.938 | 0.941 |
| | $R_nS_n$ | 0.936 | 0.937 | 0.936 | 0.938 | 0.945 | 0.952 | 0.959 | 0.968 |
| AUTO | $R_0R_n$ | 0.995 | 0.989 | 0.986 | 0.979 | 0.968 | 0.961 | 0.956 | 0.946 |
| | $S_0S_n$ | 0.990 | 0.986 | 0.979 | 0.974 | 0.967 | 0.973 | 0.975 | 0.972 |
| CROSS | $R_0S_n$ | 0.926 | 0.923 | 0.922 | 0.915 | 0.909 | 0.924 | 0.933 | 0.928 |
| | $S_0R_n$ | 0.941 | 0.934 | 0.934 | 0.938 | 0.939 | 0.936 | 0.931 | 0.930 |
| | DIFF. | -0.015 | -0.011 | -0.012 | -0.023 | -0.030 | -0.012 | 0.002 | -0.002 |
| | Z | 2.65* | 1.46 | 1.44 | 1.99* | 2.03* | 0.78 | 0.28 | 0.16 |

Industry Group 14, Computers

| CORR | VAR | LAG1 | LAG2 | LAG3 | LAG4 | LAG5 | LAG6 | LAG7 | LAG8 |
|---|---|---|---|---|---|---|---|---|---|
| SYNCH | $R_0S_0$ | 0.994 | 0.995 | 0.996 | 0.996 | 0.997 | 0.998 | 0.999 | 0.998 |
| | $R_nS_n$ | 0.992 | 0.992 | 0.992 | 0.992 | 0.992 | 0.993 | 0.994 | 0.995 |
| AUTO | $R_0R_n$ | 0.996 | 0.987 | 0.974 | 0.966 | 0.969 | 0.972 | 0.980 | 0.982 |
| | $S_0S_n$ | 0.998 | 0.995 | 0.992 | 0.989 | 0.990 | 0.991 | 0.991 | 0.991 |
| CROSS | $R_0S_n$ | 0.993 | 0.991 | 0.987 | 0.984 | 0.988 | 0.991 | 0.994 | 0.995 |
| | $S_0R_n$ | 0.989 | 0.981 | 0.973 | 0.968 | 0.968 | 0.970 | 0.975 | 0.975 |
| | DIFF. | 0.004 | 0.010 | 0.014 | 0.016 | 0.020 | 0.021 | 0.019 | 0.020 |
| | Z | 3.66* | 4.73* | 5.08* | 4.92* | 5.35* | 0.36 | 1.9 | 6.48* |

* Significant at alpha of less than 0.05

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