# Evidence of Intertemporal Systematic Risks in Daily Stock Prices Revisited

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*This paper investigates the intertemporal cross dependencies in daily stock price data following the approach of Hawawini and Vora (1980) using samples covering the period 1981-1990. It is hypothesized that Hawawini and Vora's finding of intertemporal cross dependencies is the result of nonsynchronous trading. To test this hypothesis, separate samples of frequently traded stocks and less frequently traded stocks are analyzed. We find the same general patterns of intertemporal cross dependencies as do Hawawini and Vora, but we also find statistically significant differences between low volume and high volume stocks which is consistent with the hypothesis that nonsynchronous trading contributes to these patterns.*

## INTRODUCTION

A paper by Hawawini and Vora (1980) examines the intertemporal systematic cross dependence between the daily returns of securities and those of a market index. They interpret their empirical findings as being consistent with the speed-of-the-price-adjustment hypothesis (SOTPAH). This hypothesis states that the prices of different securities will adjust to new systematic information with different speeds—some adjust immediately, while others may take several days.

Assuming the SOTPAH is true, the market index will be an average of some prices that have adjusted fully to new systematic information and some that have not. As Hawawini and Vora argue, this implies that securities that adjust immediately and fully will appear to lead the market index. This must be balanced by other securities that follow the market index. Hawawini and Vora also argue that the number of securities leading and lagging the market should decline as the length of the time interval increases. They find that data from the period 1962-1976 do exhibit both of the above phenomena.

While we do not dispute that the Hawawini and Vora findings are consistent with the SOTPAH, we argue that these findings could be explained just as easily by nonsynchronous trading. Suppose the SOTPAH is false—there is no difference in the speed-of-the-price adjustment across firms. Further suppose that new information regularly arrives before daily prices are recorded, and some securities trade more frequently than others. The observed value of the market index will be an average of prices of securities that trade subsequent to the arrival of the information and prices of securities that do not trade subsequent to the arrival of the information. Those securities that trade more frequently will

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be more likely to have observed prices that incorporate the information. Thus, some securities will appear to lead the market while others will appear to lag the market.

Alternatively, suppose the SOTPAH is true. One may next ask what the source of the differing speeds of adjustment is. It could be nonsynchronous trading. The weakness of the SOTPAH is that it does not specify the source of the differing speeds of adjustment.

The purpose of this research is to test whether intertemporal systematic cross dependencies are the result of nonsynchronous trading. In other words, we seek to determine whether the phenomenon Hawawini and Vora labeled SOTPAH is attributable to nonsynchronous trading or some other factor. Empirical research investigating nonsynchronous trading as a cause of intertemporal dependencies has been conducted by others both prior to Hawawini and Vora's study (e.g., Scholes and Williams, 1977) and subsequently (e.g., Atchison *et al.*, 1987); however, Hawawini and Vora's interpretation of their findings (disregarding nonsynchronous trading) has been unchallenged in the literature.[1] Another important justification for this study is to determine whether the relationships Hawawini and Vora found in the 1960s and 1970s continue to hold in the 1980s.

## METHODOLOGY

We utilize daily with dividend return data from the Center for Research in Security Prices covering the ten year period from January 1, 1981 through December 31, 1990. We first divide the period into five separate two year periods following the approach of Hawawini and Vora who seek to investigate the temporal stability of the empirical findings. We restrict the study to securities with no missing data during the relevant two year period. We select a sample of 100 frequently traded firms and a sample of 100 less frequently traded firms by constructing the average trading volume of each firm over the period and ranking the firms. The top 100 are used in the first sample, and the bottom 100 are used in the second sample. This process is repeated for each of the five periods studied. The mean volumes for each sample are reported in Table 1. The CRSP value-weighted index is used to measure the market.

**Table 1—Mean Trading Volume by Sample**

| Time Period | 1981-1982 | 1983-1984 | 1985-1986 | 1987-1988 | 1989-1990 |
|---|---|---|---|---|---|
| Low Volume Firms | 6600 | 7738 | 8719 | 9911 | 10457 |
| High Volume Firms | 212709 | 337873 | 490080 | 721872 | 655436 |

Numbers are the average daily trading volume over the two year period

Following Hawawini and Vora, who followed Francis (1975), the market model is estimated using various leads and lags of the market index. We have:

[1] Hawawini and Vora conduct separate analyses of NYSE and AMEX stocks—one could argue that this constitutes a test of the nonsynchronous trading hypothesis. Nevertheless, Hawawini and Vora do not address this possibility explicitly. Additionally, some AMEX stocks trade more frequently than some NYSE stocks, so any test based on that dichotomy will lack power.

(1) $R_{i,t} = \alpha_{i,t} + \beta_{i,k} R_{m,t+k} + e_{i,t}$

where:

k = -20, -15, -10, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 10, 15, 20.

Thus, leads and lags of the market by up to 20 trading days are investigated. Negative values of k are used to indicate leads, and positive values of k are used to indicate lags.

For each of the 200 securities for each of the five subperiods, 17 regressions using various values of k are estimated. This yields 17,000 estimates of beta and its t-statistic.

## RESULTS

Table 2 reports the proportion of significant betas by subperiod for each lead and lag value for both high volume and low volume firms. Table 2 shows patterns similar to those reported by Hawawini and Vora in their Table 1. There are pervasive lead/lag effects that generally decline with the length of the lead/lag. The emphasis of the present study, however, is on differences between high volume and low volume firms. Further examination of Table 2 suggests that there is a greater tendency for high volume firms to have a significant beta when the market index is led by one day. There is also a greater tendency for low volume firms to have a significant beta when the market index is lagged one day. In order to test this hypothesis further, z-statistics are calculated and reported in Table 3. The null hypothesis is that the proportion of significant betas is the same for both high and low volume firms. Our alternative hypothesis is that a higher proportion of high volume firms will lead the market and a lower proportion of high volume firms will lag the market. Let $P_h$ represent the proportion of high volume firms with significant betas and $P_L$ represent the same for low volume firms. Our hypotheses are then:

**Table 2—Percent of Significant Betas by Sample and Lead (Lag) Length**

| | High Volume Firms | | | | | Low Volume Firms | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| k | 81-82 | 83-84 | 85-86 | 87-88 | 89-90 | 81-82 | 83-84 | 85-86 | 87-88 | 89-90 |
| -20 | 10 | 4 | 2 | 0 | 3 | 1 | 7 | 6 | 4 | 5 |
| -15 | 8 | 11 | 4 | 0 | 4 | 4 | 4 | 1 | 7 | 2 |
| -10 | 7 | 9 | 6 | 7 | 7 | 4 | 3 | 5 | 6 | 5 |
| -5 | 5 | 4 | 1 | 36 | 0 | 4 | 5 | 8 | 28 | 8 |
| -4 | 4 | 7 | 1 | 13 | 9 | 9 | 7 | 0 | 7 | 5 |
| -3 | 8 | 9 | 6 | 30 | 10 | 14 | 8 | 6 | 17 | 6 |
| -2 | 8 | 4 | 9 | 46 | 9 | 9 | 16 | 7 | 34 | 21 |
| -1 | 24 | 19 | 25 | 40 | 21 | 74 | 59 | 55 | 79 | 52 |
| 0 | 100 | 100 | 99 | 100 | 99 | 98 | 98 | 93 | 97 | 85 |
| 1 | 36 | 41 | 35 | 45 | 28 | 8 | 4 | 16 | 26 | 8 |
| 2 | 5 | 4 | 3 | 37 | 7 | 2 | 1 | 3 | 25 | 8 |
| 3 | 8 | 11 | 3 | 18 | 8 | 4 | 7 | 7 | 32 | 1 |
| 4 | 4 | 6 | 3 | 36 | 18 | 4 | 7 | 7 | 8 | 8 |
| 5 | 1 | 7 | 5 | 40 | 2 | 6 | 8 | 9 | 19 | 4 |
| 10 | 3 | 9 | 6 | 3 | 0 | 6 | 9 | 5 | 8 | 8 |
| 15 | 9 | 10 | 4 | 3 | 5 | 10 | 5 | 5 | 5 | 5 |
| 20 | 10 | 1 | 5 | 2 | 9 | 10 | 3 | 5 | 3 | 4 |

**Table 3—Z-Statistics[1]**

| k | 81-82 | 83-84 | 85-86 | 87-88 | 89-90 |
|---|---|---|---|---|---|
| -20 | 2.85 | -0.93 | -1.45 | -2.04* | -0.72 |
| -15 | -1.20 | 1.90 | 1.37 | -2.74* | 0.83 |
| -10 | 0.93 | 1.80 | 0.31 | 0.29 | 0.60 |
| -5 | 0.34 | -0.34 | -2.42* | 1.22 | -2.95* |
| -4 | -1.44 | 0.00 | 1.01 | 1.42 | 1.11 |
| -3 | -1.36 | 0.25 | 0.00 | 2.19 | 1.05 |
| -2 | -0.25 | -2.89* | 0.52 | 1.75 | -2.41* |
| -1 | -8.17* | -6.36* | -4.55* | -6.12* | -4.81* |
| 0 | 1.43 | 1.43 | 2.19* | 1.76 | 3.78* |
| 1 | 5.08* | 6.99* | 3.16* | 2.86* | 3.81* |
| 2 | 1.16 | 1.37 | 0.00 | 1.85* | -0.27 |
| 3 | 1.20 | 0.99 | -1.30 | -2.32 | 2.42* |
| 4 | 0.00 | -0.29 | -1.30 | 5.08* | 2.13* |
| 5 | -1.94 | -0.27 | -1.11 | 3.35* | -0.83 |
| 10 | -1.03 | 0.00 | 0.31 | -1.56 | -2.95 |
| 15 | -0.24 | 1.35 | -0.34 | -0.72 | 0.00 |
| 20 | 0.00 | -1.01 | 0.00 | -0.45 | 1.44 |

[1]Tests of the hypothesis that the proportion of significant betas is the same for the sample of low volume firms as for the sample of high volume firms

* Significant at the 5 percent level

(2a) $H_O = P_H = P_L$

(2b) $H_A = P_H > P_L$ for leads

(2c) $H_A = P_H \neq P_L$ for contemporaneous returns

(2d) $H_A = P_H < P_L$ for lags.

Thus, we use a one tailed test when k is not equal to zero. Setting the significance level at 5 percent and noting that the z-statistic is calculated using $P_H - P_L$, we use the following criteria to reject the $H_0$:

(3a) $z > 1.64$ for leads

(3b) $|z| > 1.96$ for contemporaneous returns

(3c) $z < -1.64$ for lags.

According to Table 3, the null hypothesis is rejected 22 times at 5 percent significance which is 25.9 percent of the possible times. Under the null hypothesis that there is no difference between low and high volume firms, the z-statistics reported in Table 3 are independent standard normal. Thus, we also can test the null hypothesis that the difference in the sample proportions of significant betas is jointly zero using a chi-square statistic. The value for this test statistic is 494.7 with 85 degrees of freedom. The critical value for a chi-square with 85 degrees of freedom and 5 percent significance is 107.52. This is convincing evidence that there are differences in the intertemporal cross dependencies for high and low volume firms.

In an effort to reduce the effect of systematic risk on the results, the analysis is repeated forming portfolios of ten securities each. These portfolios are formed from the same 200 securities on the basis of trading volume. Seventeen regressions using various values of k are estimated for each of the 20 portfolios for each of the five subperiods, yielding an additional 1,700 regressions. These results are reported in Table 4 and confirm the conclusion that differences in high volume and low volume firms exist. All ten low volume portfolios for all five periods exhibit significant betas when k equals –1, whereas less than 20 percent of the high volume portfolios do. On the other hand, most of the high volume portfolios exhibit significant betas when k equals +1, whereas less than 20 percent of the low volume firms do. Additionally, most of the significant betas disappear for leads and lags greater than one day.

**Table 4—Number of Portfolios With Significant Betas by Sample and Lead (Lag) Length**

| | High Volume Firms | | | | | Low Volume Firms | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| k | 81-82 | 83-84 | 85-86 | 87-88 | 89-90 | 81-82 | 83-84 | 85-86 | 87-88 | 89-90 |
| -20 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| -15 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| -10 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -5 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 4 | 0 |
| -4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -3 | 1 | 1 | 1 | 4 | 1 | 4 | 2 | 1 | 1 | 0 |
| -2 | 0 | 0 | 1 | 7 | 0 | 3 | 5 | 0 | 4 | 5 |
| -1 | 2 | 2 | 4 | 1 | 0 | 10 | 10 | 10 | 10 | 10 |
| 0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 1 | 9 | 10 | 10 | 4 | 8 | 2 | 0 | 5 | 1 | 1 |
| 2 | 0 | 1 | 0 | 5 | 0 | 0 | 0 | 0 | 3 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 8 | 0 |
| 4 | 0 | 0 | 0 | 6 | 1 | 0 | 1 | 0 | 0 | 1 |
| 5 | 0 | 0 | 0 | 7 | 0 | 1 | 0 | 0 | 2 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 |
| 15 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| 20 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 0 |

As a final comment on the results, we note that there are some unexplained discrepancies between our results and those of Reinganum (1982). Reinganum also regresses portfolio returns on leads and lags of the market return when investigating the small firm effect. Because Reinganum forms portfolios based on the market value of equity capitalization rather than the dollar value of trading volume, the studies are not directly comparable. Due to the high correlation between equity capitalization and trading volume, however, one would expect to find similar results.[2] Reinganum finds all portfolios—both low and high equity capitalization—to have significant betas for a k of –1. For a k of +1, none of Reinganum's high equity capitalization portfolios have significant betas, while three of five low equity capitalization portfolios have significant betas. Reinganum's data

[2] Using COMPUSTAT data we find a correlation of 0.84 between these two variables for NYSE stocks.

are from 1964 to 1978. The discrepancy in the results suggests that additional research into these relationships would be useful.

## CONCLUSIONS

This study investigates whether Hawawini and Vora's empirical findings persist through the 1980s and whether their results could be the result of nonsynchronous trading. The results show that similar patterns of intertemporal cross dependencies continued through the 1980s; however, differences in the patterns for low and high volume firms suggest that the results are at least partly attributable to nonsynchronous trading. Additionally, the results are not entirely consistent with Reinganum's work on the small firm effect which suggests that this area may yield interesting future research.

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