ΣΠΟΥΔΑΙ

Τριμηνιαία Ἐπιστημονική Ἔκδοση τῆς Ἀνωτ. Βιομηχανικῆς Σχολῆς Πειραιῶς

| ΕΤΟΣ 1982 | ΟΚΤΩΒΡΙΟΣ — ΔΕΚΕΜΒΡΙΟΣ 1982 | ΛΒ' ΤΟΜΟΣ | ΑΡΙΘΜ. ΤΕΥΧΟΥΣ 4 |
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# THE INTERVALING EFFECT UNDER NON-SYNCHRONOUS TRADING AND PRICE ADJUSTMENT LAGS IN THE ATHENS STOCK EXCHANGE

By

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ABSTRACT

This study examines the influence of the intervaling effect under non- synchronous trading and price - adjustment lags upon the beta (β) estimates of the «market model», when applied to the low-volume and infrequently trading Athens Stock Exchange. β- estimates were biased by the intervaling effect-the direction and size of such bias upon «active» and «thin» stocks, respectively, being affected by the type of market index employed. Furthermore, it was inferred that the bias is due not only to the « (Lawrence) Fisher effect» but also to the intertemporal short-term dependence of the return relatives.

## I. INTRODUCTION

Some recent research by Cohen, et al. (1980) on the emgirical robustness of the «market model» and its analytical counterpart the «CAPM» has refocused attention on the bias introduced by the intervaling effect, in terms of such under-

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lying causes as infrequently traded securities, large bid-ask spreads, and market-specific factors relating to the impact of specialists, market makers, and block traders. Indeed, the empirical tests performed on U.S.-Canadian markets by Blume **(1975),** Hawawini (1980), Scholes and Williams (1977), Schwartz and Whitcomb **(1977a** and **1977b),** Schwert (1977), Belkaoui (1977), and Fowler, et al. (1979), and on host of markets in industrialized and other countries by Altman, et al. **(1974),** Dimson (1974 and 1979), Franks, et al. (1977), Jennergren and Korsvold **(1975),** Pogue and Solnik (1974), Silber (1975), Niarchos (1972), and Emanuel (1980), invariably refer to the « (Lawrence) Fisher effect», probably caused by the infrequent traiding of securities (thinness) and the possible lag in the adjustment of security prices to new information injected in the market.

The evidence generally shows that beta estimates of frequently traded (active) securities are biased upward (downward) while the corresponding estimates for infrequently traded securities are biased downward (upward) with respect to a market index favoring the active (thin) securities. These biases are likely to be stronger in stock markets of small, developing nations, where inadequate liquidity and incomplete institutional infrastructure impede the flow and utilization of information-hence the frequency of trading-and induce large operational costs (bid-ask spreads).[1] Indeed, the extensive utilization of the market model in empirical financial research calls for diagnosing the intensity of the intervaling effect in the estimation of beta, in order to assess the necessity for the corrective suggestions proposed by Scholes and Williams (1977), Cohen et al. (1978), and Dimson (1979). In this vein, we have undertaken an empirical investigation of the Athens Stock Exchange (ASE), that seems to be characterized by most of the imperfections outlined above and has not been studied before in appropriate detail save for the early work by Niarchos (1972) on ASE efficiency. Specifically, the ASE is a small secondary market, characterized by the lack of an organized professional investment community, the absence of market makers to provide normal liquidity, and by infrequently traded securities. Due to the above attributes and the concomitant thinness of the market, it is expected that operational frictions and information lags will affect stock returns.

Based on a sample of daily closing prices, we obtain individual and average beta estimates for active and inactive (thin) stoks over six differencing intervals by utilizing three indices - an Equally Weighted (EWI), a Value - Weighted (VWI), and the ASE Constant - Weights Index (CWI). From these estimates, we study

1. See Granger (1975), for a comprehensive survey of previous empirical studies and an implicit appeal for further testing under various institutional regimes.

the intervaling effect, (a) with respect to the direction of the bias across stocks for each index and return interval ; and (b) with respect to the degree of volatility of the beta estimates over different - length intervals across the stocks and the indices. The results strongly support the presence of the intervaling effect and the dependence of its intensity on the type of the market index used. These results are due non only to the non- synchronous trading of the stocks but also to their serial correlation in return space - an evidence of price adjustment delays.

Section II presents the problem and reviews briefly the relevant literature. Section III describes the data and methodology, while Sections IV and V focus no a discussion of the results and some brief concluding remarks.

## II. LITERATURE REVIEW

The generating process for security returns may be described by the simple logaritmic form of the market model :

$$\ln(1+r_{jt})=\alpha_j+\beta_j \ln (1+r_{mt})+u_{jt}, \tag{1}$$

where $r_{mt}$ and $r_{jt}$ are the return on the market portfolio and on the $j^{th}$ security respectively, during time t ; $a_j$ and $\beta_j$ are the regression parameters ; and the standard assumptions for an unbiased estimate of $\beta$ under the regime of OLS are observed[2]. Under these assumptions the length of the return interval will not affect the values of $\beta$. However, for several reasons, referring either to the data collection method or to existing operational inefficiencies in the trading of securities, the length of the differencing interval does impact on the estimation of $\beta$.

Several explanations have been offered for the observed biases in $\beta$ estimates. Fisher (1966), observed that discontinuous trading yields non-synchronous observations in stock market index construction, resulting in the presence of positive autocorrelation of the index returns and negative autocorrelation of the residuals. Known as the «Fisher effect», this phenomenon has been investigated further by several researchers. For example, Schwartz and Whitcomb (1977a), attempted to explain the direct relation between $\beta$ and the return interval length by means

2. The following standard assumptions are made about the behavior of the error terms : (1) the expected value, $E(u_{jt}) = 0$, for all j and t ; *(2)* he variance, $\sigma^2 (u_{jt})$, and the contemporaneous covariances, $Cov(u_{jt},u_{it})$, are independent of t ; (3) the lagged covariance, $Cov (u_{jt}, u_{it}+\tau)= 0$ for all j and i when $\tau$ 0.

of the time - variance relationship, while Hawawini (1980), generalized these results by means of the time - covariance function in a framework of short - run return dependencies and cross-dependencies. Also in parallel studies, Scholes and Williams (1977) and Dimson (1979) have found empirical evidence that daily closing prices from non-synchronous trading points introduce errors-in-the-variables of the market model.

More recent research into the theoretical microstructure of capital markets by Cohen et al. (1979 et 1980) has suggested that the autocorrelation of returns and cross-correlation patterns can be attributed to such operating factors as specialist intervention, bid-ask spreads, and heterogeneous portfolio adjustment lags for individual traders. Such factors, in addition to the non-synchronous trading patterns, impede the frequency of trading and also introduce price adjustment delays. Moreover, these frictions and delays are more likely to affect thin securities that lack a sufficiently liquid market.3 Thus, as a result, an index constructed mostly with actively traded stocks will yield upward-biased betas for these securities and downward - biased betas for the less active stocks. As a corollary, the betas of active stocks will fall and the betas of inactive stocks will rise, given an increase in the length of the returns interval[4].

## III. DATA AND METHODOLOGY

The data base consists of daily closing prices[5] for 25 common stocks with trading continuity on the Athens Stocks Exchange (ASE) during the period of

3. Although both the non-synchronous trading and the return auto-correlations are responsible for the bias related to the intervaling effect, they do stand apart from the viewpoint of market efficiency. Namely, the serial dependence of returns betrays a slow adjustment of prices to new information - an evidence of weak-form inefficiency. This is not necessarily true for the «Fisher effect» resulting from the time disparity in the trading across stocks.

4. The tendency of the beta estimates to reach asymptotically their true values as the interval length increases, is due to the fact that returns measured over longer intervals are affected less by the «Fisher effect» of asynchronous trading and they also reflect a larger portion of the corresponding information set.

5. The price data were collected from the Book of Daily Closing Prices maintained by the ASE, where, according to established practice, a recorded closing price may be the result of an actual transaction, a bid, or an ask. Quoted prices recorded at the close of a market day reflect more information than the preceding transaction price. Moreover, quoted prices are less sensitive to possible imbalances in supply and demand. This, of course, implies that the quoted price series are less volative than transactions price series. See Cohen, Maier, et al. (1978).

January 2, 1970, to December 31, 1975. 6 Prices and dividends, expressed in Greek monetary units (drachmae), were properly adjusted for stock-splits, stock - dividends, and rights - offerings before three market indices were constructed - a Value-Weighted (VWI), an Equally-Weighted (EWI), and an ASE equivalent Constant-Weights Index (CWI).[7] The ASE, like any other exchange, functions as an action market for many buyers and sellers through the intermediation of brokers or their legal representatives. Brokers transact business on behalf of clients as well as on their own account. However, they are under no obligation to make a market and, hence, their own trading is not aimed at this goal. All stocks are divided into groups - generally along industry lines-and trading takes place in consecutive 20-minute intervals for each group. If signiticant news is released during the day, trading cannot resume on the stocks whose trading period has ended.[8]

The 25 securities were classified into two groups of active and thin stocks in terms of an index of trading continuity and an index of relative marketability. The trading continuity index of each stock was computed as the ratio of the no-trading days over the total number of trading days within each of the six years The relative marketability index of each stock was computed as the ratio of its share traded within each month over the total number of shares traded for the 25 issues of the sample ; then we averaged the ratios of the 12 months of each year

6. At the beginning of the study, about 72 stocks were traded in the ASE. From this population, we took all securities with enough trading continuity to provide a workable time series of daily prices.

7. For each interval t, the Equally-Weighted Index was computed $EWI_{t,\tau} = \sum_{i=l}^{\eta}$ where $r_{i,t,\tau}$, is the simple rate of return of stock i over the $\tau$-days long interval t, and $\eta$ is the number of stocks with returns in the t interval. The Value-Weighted Index was computed like the S & P Price Index. That is, the price of each stock was weighted by the proportion of its value in the total market value of the 25-stock portfolio. The dividend return of this portfolio was added to the price relative. The ASE Constant-Weights Index was calculated by forming an hypothetical portfolio in which Drs. 100,000 were invested on each stock in the base period January 1970. Over time, the number of shares of each stock «purchase» originally remained constant while prices changed periodically. Thus, the weights given by the number of shares per stock over the total number of shares «purchased» during, the base period were constant through time. The dividend return on this portfolio was added to obtain the full CWI return-relative for each interval.

8. This restriction clearly results in non - synchronous closing prices, and hence, the «Fisher Effect» is present by necessity.

to find the average month relative marketability index for each year.[9] To test for the reliability and consistency of the rankings according to these two proxies, we computed the degree of association for annual pairing in the 6-year horizon.

The rankings for consecutive years were highly correlated, while those for non - consecutive years were still quite strong. Specifically, in consecutive years we obtained for both criteria coefficients as high as .94 and not lower than .7, while for five-year comparisons the coefficients were not lower than 50[10]. The classification of securities as active or thin proceeded on the basis of how frequently each stock had ranked among the 13 most active issues by means of either criterion during 1970-75. Thirteen securities that satisfied this requirement were considered as active, while the remaining twelve were labeled as thin.[11] Following the above classifications, we computed the individual security and corresponding market index returns vectors each of the 25 stocks and each of the three indices over differencing intervals of $\tau = 1, 2, 3, 5, 10$ and 20 days. Using OLS regressions, we obtained estimates of market model betas for each stock and interval for each of the three indices. Finally, for each interval, the estimated beta values were pooled together to compute their averages with respect to each classification and index.

According to the discussion in Section II, if the index returns were computed from synchronous price data and there were no price adjustment lags, the differencing interval should not influence the estimated beta values. These values should be approximately equal, apart from any sampling error, or their ratios over any pair of intervals should be equal to unity. Hence, a simple approach to test the stability of the beta estimates was devised as follows : for each stock we computed the ratio of its beta values for all 15 available pairs of intervals. Then we computed the square deviations of the ratios from unity, summed over all squared values and divided by 15. Analytically we had,

$$d = \sqrt{\sum_{i=1}^{15} (r - 1)^2 / 15}$$

9. Due to the nonavailability of data for 1971, the relative marketability index was computed only for the 5 - year period 1971 - 1975.

10. Detailed tables have been omitted for the sake of compactness.

11. Contributing to the reliability of the classification was the fact that of the 13 active securities, 12 had consistently over the years the largest number of shareholders.

In order to assess which index gave the least volatile beta estimates over the different intervals, we computed the average d–value for the active and the thin stocks respectively within each index. As was mentioned above, stocks in the ASE are traded in the typical sequential fashion found in Europe and Latin America. In view of this particular institutional arrangement we had to check whether the «early» or «late» trading of the stocks introduced a pattern of bias in their beta estimates different from that resulting from their classification as active or thin. Thus, we grouped the 25 issues about evenly into 13 stocks traded «early» and 12 traded «late», and then we performed the same measurements on these groups as well.

Finally in order to ascertain whether the bias in beta is also the product of trading frictions and slow adjustment to new information, we computed the serial correlation coefficients of the natural logarithms of price–cum–dividends daily differences for lags up to 10 trading days.[12] Whereas the «Fisher effect» introduces bias in the estimation of betas due to the construction of the index from non – synchronous stock returns, the serial dependence of individual stock returns biases the betas through differences in the return autocorrelation pattern across stocks, which introduces a lagged relationship in the market model.

## IV. RESULTS

The average estimates of beta values for the active and thin stocks, respectively, are shown in Table 1. As expected, the average beta for all 25 stocks is very close to unity in the case of the Equally – Weighted Index.[13] In four of the six intervals, the thin stocks exhibited an upward bias due to the fact that such stocks were more favorably represented in the index. Nonetheless, as the differencing interval increased, the average estimates of betas of active and thin stocks tended toward unity. This confirms the analytical and empirical results of Scholes and Williams (1977) and Dimson (1979).

With respect to the Value – Weighted (VWI) and the Constant – Weights Indi-

12. It must be noted that the price – cum – dividends differences of the time series were computed only over those intervals for which the beginning and ending trading days had price quotations.

13. The slight deviation from unity is due to the fact that in some periods there were no return observations for all the 25 stocks because of nontrading. Hence, the arithmetic average was biased toward stocks with greater trading continuing.

TABLE 1

SIMPLE ARITHMETIC AVERAGES OF BETAS FOR VARIOUS RETURN INTERVALS

| Intervals | EWI | | | VWI | | | CWI | | |
|---|---|---|---|---|---|---|---|---|---|
| Days | Active | Thin | All* | Active | Thin | All* | Active | Thin | All* |
| 1 | .886 | 1.070 | .978 | .821 | .769 | .795 | .730 | .808 | .769 |
| 2 | .925 | 1.054 | .989 | .860 | .778 | .819 | .772 | .868 | .820 |
| 3 | 1.014 | .965 | .989 | 1.012 | .786 | .899 | 1.101 | .935 | 1.018 |
| 3 | .971 | .897 | .934 | .912 | .598 | .755 | 1.072 | .891 | .981 |
| 10 | .934 | 1.012 | .973 | .916 | .804 | .860 | .989 | .916 | .952 |
| 20 | .984 | 1.012 | .998 | .967 | .884 | .925 | .882 | 1.125 | 1.003 |

* It should be noted that the average values of betas given, being simple arithmetic averages would approach unity only for the Fisher Arithmetic Index (EWI) by construction.

ces (CWI), the îollowing observations can be made. The beta averages for all stocks are considerably lower for intervals of one and two days long ; they do rise, however, as the interval becomes longer. Furthermore, we notice that the direction of the beta estimation bias is different for active and thin stocks across the VWI and CWI. In particular, active stocks had beta averages higher than thin stocks for all intervals associated with the VWI. The results are mixed in the case of the CWI, although for short intervals (up to two days) the thin stocks have higher beta averages. Results demonstrating the tendency of the beta estimates to rise with the differencing interval have also been reported in empirical studies by Schwartz and Whitcomb (1977b) Pogue and Solnik (1974), and Smith (1978).

In addition to discerning the direction of bias introduced in the beta estimates across stocks and types of indices, it is also important to check the intensity of the intervaling effect, that is, how volatile the estimated betas become as the interval length changes. The average d-values shown below demonstrate that active stocks were the least affected by the intervaling effect. In terms of indices, the Equally - Weighted index had certainly the best performance yielding the most stable estimates for both groups of active and thin stocks.[14]

| | Active Stocks | Thin Stocks |
|---|---|---|
| Equally-Weighted index (EWI) | d= .069 | d=.170 |
| Value - Weighted index (VWI) | d = . 157 | d = . 384 |
| Constant - Weights index (CWI) | d=.146 | d=.517 |

We now turn to the results of the intervaling effect on the beta estimates of «early» and «late» traded stocks. It should be noted that among stocks of equal trading frequency and liquidity, those traded late should have estimates upward-biased relative to the betas of stocks traded early. It so happens for our sample of the 25 stocks that all but 2 of the active stocks are «early» traded and all but 2 of the thin stocks are «late» traded. Thus, we should not expect significant differences in the pattern of the beta- bias across the three indices. Indeed, looking at Table 2, we notice that the average beta estimates of «early» and «late» traded stocks are not really biased differently that those of active and thin stocks-not

14. The d-values of one of the thin stocks were omitted in the calculation of the average d-value for their stocks in the case of the Value- Weighted and the Constant - Weights Indices, because they were extremely high. Had they been included, they would have simply reinforced the reported results.

15. See explanation in footnote 14, above.

### TABLE 2
### SIMPLE ARITHMETIC AVERAGES OF BETA ESTIMATES FOR VARIOUS RETURN INTERVALS

| Intervals | EWI | | VWI | | CWI | |
|---|---|---|---|---|---|---|
| Days | Early | Late | Early | Late | Early | Late |
| 1 | .905 | 1.048 | .843 | .743 | .716 | .820 |
| 2 | .937 | 1.041 | .880 | .755 | .773 | .865 |
| 3 | 1.015 | .964 | .1028 | .767 | 1.124 | .908 |
| 5 | .993 | .874 | .921 | .587 | 1.092 | .868 |
| 10 | 1.009 | .931 | .963 | [illegible] | 1.039 | .860 |
| 20 | 1.089 | .898 | 1.029 | .816 | .950 | 1.051 |

a surprising finding given the nearly perfect equivalence of the two classifications.

We also see below that according to the average d-values the beta estimates of the «early» stocks are less volatile than those of the «late» stocks, and this coincides with the relative performance of the active and thin stocks reported earlier in with the relative performance of the active and thin stocks reported earlier in this connection. However, it is apparent that the difference in volatility between «early» and «late» stock betas is not as large as the one associated with the active and thin stocks. Again the Equally-Weigthted Index appears to give the most stable estimates of beta[15].

| | Early | Late |
|---|---|---|
| Equally - Weighted Index (EWI) | d = .113 | d= .121 |
| Value - Weighted Index (VWI) | d = . 177 | d = . 360 |
| Constant - Weights Index (CWI) | d = . 215 | d = . 435 |

Table 3 shows that indeed the stocks of this study exhibited considerable serial dependence in their returns. It is also evident that the degree of serial correlation diminishes rapidly to insignificant levels as the lag increases. Thus in conjuction with the attenuating «Fisher effect» over long intervals, the downward tendency of the serial correlation helped to lessen the beta estimation bias in the larger return intervals.

TABLE 3

AVERAGE ABSOLUTE VALUES OF SERIAL CORRELATION COEFFICIENTS

| Groups \ Lags | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Active | .23 | .05 | .011 | .09 | .05 | .05 | .03 | .02 | .02 | .03 |
| | (12) | (5) | (12) | (9) | (7) | (6) | (2) | (0) | (0) | (0) |
| Thin | .19 | .05 | .07 | .09 | .14 | .05 | .04 | 0.5 | .04 | .03 |
| | (12) | (2) | (3) | (4) | (5) | (2) | (1) | (2) | (0) | (0) |
| ALL | .211 | .050 | .091 | .086 | 0.96 | .048 | .035 | .031 | .029 | .034 |
| | (24) | (7) | (15) | (13) | (12) | (8) | (3) | (2) | (0) | (0) |

* A lag of n days refers to the correlation of daily log-return relatives n-trading days apart. The number of correlation coefficients found significant at he 0.05 level are given in parentheses.

## V. CONCLUDING REMARKS

Estimates of betas of stock returns observed in a low-volume and infrequently trading markets like the ASE were found to be biased by the intervaling effect. It was shown that the direction and the size of the beta bias for each group of stocks - active or thin-were affected by the type of the market index used. Judging in terms of the volatility of the beta estimates over different-length intervals, it was found that the Equally Weigthed index was most suitable proxy for the market portfolio return. On the contrary, the type ,of index computed currently by the ASE seems to introduce more strongly the intervaling effect. Furthermore, it was inferred that the bias is due not only to the «Fisher effect» but also to the intertemporal short-term dependence of the return relatives.

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