

**DIRECT EVIDENCE OF NON-TRADING OF
NYSE AND AMEX STOCKS**

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ABSTRACT

This paper documents the frequency of non-trading for NYSE and AMEX stocks based on information in the CRSP monthly and daily data files. We find a declining pattern of non-trading over the 1926 to 1990 period: 23.4 percent of NYSE stocks do not trade on an average (end-of-month) day during the 1926 to 1945 period, compared with 1.29 percent on average over all days during the 1973-1990 period. In the 1973-1990 period, non-trading averaged more than 15 percent for AMEX firms. We find that the average amount of non-trading is larger for smaller stocks, is lowest at the end of the year, and tends to be lowest at the beginning of the week and highest at the end of the week. We also find substantial heterogeneity in the amount of non-trading across the stocks within each size decile. For example, while 10 percent of the stocks in the smallest decile trade virtually every trade day, 10 percent of the stocks in that decile do not trade on 51 percent of the trade days during the year, and one percent do not trade on 76 percent of the trade days during the year. Finally, we briefly discuss some implications of our non-trading evidence for measured autocorrelations.

Direct Evidence of Non-Trading of NYSE and AMEX Stocks

Empirical research in financial economics has long recognized that infrequent or nonsynchronous trading can result in measurement error in security returns. Studies have also examined the impact of infrequent trading on risk measurement and autocorrelation of returns.¹ However, few studies have directly examined the extent to which non-trading exists in the data.² Given the increasing emphasis placed on potential biases in estimated moments due to market frictions like non-trading, examination of the actual contamination of the data due to non-trading is essential.³

This paper documents cross-time and cross-security patterns in non-trading during the 1926 to 1990 period. We identify non-traded stocks by exploiting the convention for recording the prices of non-traded securities employed by the Center for Research in Security Prices (CRSP). Specifically, when a stock does not trade, CRSP records the price as the *negative* value of the average of the last bid and ask price. We find that, on average, over 23 percent of NYSE securities failed to trade on a given day during the period from 1926 to 1945; between 1946 and 1963, this number drops to 7.7 percent; and over the last decade of the study, non-trading is approximately one percent. We also examine trading frequency by month and by day, by exchange, and for securities in deciles ranked by market value of equity. The evidence indicates that as many as 75 percent of the prices used to compute small stock portfolio returns were not actual transaction prices during the first ten years of the CRSP history of returns. Between 1973 and 1990, on average, 24 percent of NYSE and AMEX stocks in the smallest size decile failed to trade on a given day. We also find substantial heterogeneity in the amount of non-trading across the stocks within

¹Fama (1965) and Fisher (1966) examine infrequent trading and the measurement error in security returns. Scholes and Williams (1977), Dimson (1977), Cohen, Hawawini, Maier, Schwartz and Whitcomb (1983), Fowler and Rourke (1983), and Dimson and Marsh (1983) examine the impact of infrequent trading on risk measurement. Perry (1985), Atchison, Butler and Simonds (1987) and Lo and MacKinlay (1990a, 1990b) examine the impact of infrequent trading on autocorrelation of returns.

²A few exceptions are Lakonishok and Smidt (1984) and Keim (1989) who examine non-trading around the turn-of-the year; and Lo and MacKinlay (1990a) who examine month-end non-trading between 1973 and 1987.

³In this paper we refer to non-trading as the failure of a stock to trade over a particular period (usually one day) when the NYSE and AMEX are open for trading. Thus, our non-trading definition is more extreme than nonsynchronous trading, whereby the final transaction prices of two stocks may be recorded at different times within a particular day.

each size decile. For example, while 10 percent of the stocks in the smallest decile trade virtually every trade day, 10 percent of the stocks in that decile do not trade on 52 percent of the trade days during the year, and one percent do not trade on 76 percent of the trade days during the year. Finally, we find that during the 1964 to 1972 period the CRSP files do not flag non-traded stocks by a negative price. Much recent research relating to non-trading is unaware of this omission, and the reported results may be impacted. For example, researchers attempting to cleanse the data of non-traded securities will unknowingly include many non-traded stocks during the 1964-1972 period.

Our results provide useful bounds for other studies related to non-trading. As an example, we revisit the relation between non-trading and estimates of autocorrelation, and find mixed results. Our evidence for the 1973-1990 period casts some doubts on previous research that concludes non-trading cannot explain the positive return autocorrelations found in portfolios of common stocks. However, in the 1928-1940 period when non-trading was at its highest levels, the autocorrelations of the daily S&P Composite Index were at the lowest levels during our entire sample period.

The paper is organized as follows. Section I presents NYSE non-trading evidence from 1926 to 1990, relates non-trading to the size (market value of common equity) of the firm, and examines daily and monthly patterns of non-trading of NYSE and AMEX securities over the more recent 1973 to 1990 period. Section II uses these stylized facts to reexamine the relation between non-trading and estimates of portfolio autocorrelations. Section III concludes the paper.

I. Non-trading Evidence

We document the amount of non-trading among NYSE and AMEX stocks. The data are obtained from the daily and monthly stock price files provided by CRSP. The monthly file contains prices for NYSE stocks for the period December 1925 to December 1990. The daily file contains prices for both NYSE and AMEX securities from July 1962 to December 1990. If no trade occurs on the actual trading day in the case of the daily files, or the last trading day of the month in the case of the monthly files, then the average of the bid and ask prices is entered as a negative value.

We exploit this convention in the CRSP files to compute the percentage of stocks that did not trade during a particular interval. In particular, we compute the percentage of total NYSE stocks that did not trade on the last day of each month during the 1926 to 1990 period. For the more recent period from July 1962 to December 1990, we compute for each day the percentage of total NYSE and AMEX stocks that did not trade. Using these series of monthly or daily percentages, we can compute the average amount of non-trading for a particular year, month of the year, and

day of the week.

The analysis reported below excludes the years 1964 to 1972 (inclusive) because of the abnormally low number of negative prices recorded by CRSP during that period.⁴ In several of these years no prices were recorded as negative values. This finding does not indicate an absence of non-trading since a random check of month-end bid and ask prices in the *Wall Street Journal* revealed numerous securities that did not trade on the last trading day of the month during this period. Subsequent to the circulation of an earlier draft of this paper, the CRSP Stock File Guide (beginning in 1990) now warns users of the omission of the negative price convention for this period.

A. A Long Perspective, 1926 to 1990

Table I contains evidence on non-trading frequency based on information in the monthly CRSP files for the years 1926 to 1990. We report frequency distribution cutoffs (medians, 75th percentile and maximum value) for the entire sample, and for ten subgroups based on an annual year-end sort by market value of the outstanding common stock for the firms. The top row in table I reports results for all NYSE securities. During the overall period, 14.2 percent of the stocks on the NYSE did not trade on an average end-of-month day. Within-year averages (i.e., the mean of the twelve month-end trading frequencies) range from 43.3 percent in 1932 to 0.5 percent in 1987. The median across all months is 7.9 percent. We examine three subperiods: the "early" period of 1926-1945, the post-World War II period of 1946-1963, and the most recent period of usable data, 1973-1990. During the 1926-1945 subperiod, the mean (median) non-trading of NYSE securities on an average end-of-month day is 27.4 (23.4) percent. This number drops to 10.8 (7.7) percent between 1946 and 1963 and is 2.9 (0.9) percent from 1973 to 1990, indicating a general decline in the frequency of non-trading.

The remainder of table I examines the relation between non-trading and size of NYSE securities. To create the size categories, we use the "year end capitalization portfolio assignment" supplied by CRSP. Percentages of non-trading are computed at each month-end within each size category. Summary statistics reported are computed as described above.

⁴According to the CRSP Stock File Guide, the source of daily price data during this period was Standard & Poor's Price Tape. Since September 1972, data are provided by Interactive Data Corporation.

For the overall period in panel A, the smallest market value stocks have the highest mean (median) percentage of constituents that do not trade in an average month: 29.3 (25.3). Non-trading declines monotonically through the groups to a minimum value of 3.5 (1.0) percent for the largest firms.⁵ The 75th percentile and maximum non-trading percent also show monotonic patterns. Non-trading for each size group is most prevalent in the early period (panel B) than the later periods (panels C and D), and is especially pronounced for the smallest firms in the earliest years of the sample period. The largest *within-year average* for the smallest stocks is 74.8 percent (1932) versus 12.0 percent (1941) for the largest firms. With the exception of the late 1940s, when as many as 40 percent of the smaller NYSE stocks did not trade on an average month-end, the latter subperiods display substantially reduced levels of non-trading. This is evident in figure 1 which present the within-year average of the percentage non-trading for each year over the entire period for the smallest and largest size portfolio.

We also examine a month-by-month breakdown of non-trading for all securities and for the two extreme size categories. The greatest frequency of non-trading occurs in the summer months of June, July and August. The lowest level of non-trading occurs at the end of the year in November and, especially, December. These year-end results are consistent with Lakonishok and Smidt's (1984) observation (using data from 1970 to 1981) of increased trading on the last day of the year, as well as Keim's (1989) evidence (using data from 1972 to 1987). Examining the size-based results, we find a much larger decrease in the mean (median) non-trading from November to December for the smallest firms (27.0 (23.1) percent to 17.2 (13.6) percent) than the largest firms (3.1 (0.2) percent to 2.7 (0.5) percent). This tendency is robust across subperiods and is consistent with the hypothesis of increasing levels of tax-loss selling of smaller stocks as the end of the tax year approaches.⁶

In summary, our findings based on the CRSP monthly data are consistent with previous work that suggests an inverse relation between firm size and degree of non-trading. The amount of non-trading can be substantial -- particularly for smaller firms in the earlier sample years -- to an extent that 74.8 percent of the prices used to compute small firm portfolio returns in some years

⁵Stoll and Whaley (1990) uncover a monotonic relation between infrequent *intraday* trading and size during the 1982 to 1986 period for NYSE stocks.

⁶We computed F-tests of the equality of non-trading across months for the overall period (all stocks). We tested each month against *all* other eleven months. Only December is significantly different from the other eleven months.

are not based on actual transaction prices.

B. A Closer Look, 1973 to 1990

Use of the CRSP daily file permits analysis of intraweek and intramonth patterns of non-trading, as well as analysis of non-trading for American Stock Exchange (AMEX) stocks. Table II reports non-trading results based on the day-by-day percentage of negative prices relative to the entire sample, reported separately by day, month and year for the period 1973 to 1990. The overall mean percentage of non-traded securities over this time period is 6.04 percent for the combined sample of NYSE and AMEX securities, 1.39 percent among NYSE securities, and 15.86 percent among AMEX securities (medians were similar to means). Figure 2 presents graphs of daily non-trading from 1973 to 1990 for NYSE stocks (upper panel) and AMEX stocks (lower panel), respectively. In the 1970s, non-trading of AMEX (NYSE) stocks was as high as forty (eight) percent on some days. The lowest levels of non-trading occurred during the period surrounding the October 1987 market crash. Year-by-year average non-trading is roughly ten times higher among AMEX versus NYSE securities. Overall, non-trading for the smallest decile firms is 24.79 percent and for the largest decile firms is 0.16 percent.

An interesting day-of-the week pattern emerges for both NYSE and AMEX stocks: non-trading increases monotonically through the week. In conjunction with Keim's (1989) and Porter's (1992) finding of a tendency for Friday's price to close at an ask and Monday's price to close at a bid, these findings may partially account for the tendency for Monday's measured returns to be negative.

The month with the smallest incidence of non-trading for both NYSE and AMEX securities is December. The average non-trading percentage for the entire year is 6.04 percent, versus 4.17 percent for an average day in December. This confirms the inferences drawn from the month-end non-trading results presented in the previous section: non-trading during the entire month of December is lower than in other months. There also tends to be a greater incidence of non-trading during the summer and fall months: average non-trading in each month from November to April is less than 6.0 percent and in each month from May to October is greater than 6.2 percent.

Recall that the monthly non-trading results reported in the previous section are based on the last trading day of the month. Using the CRSP daily file, we find that, in most cases, the incidence of non-trading (i.e., the occurrence of negative prices) for the NYSE firms is statistically the same for the last trading day of the month as for the other days. One exception is December

where there is a statistically lower incidence of negative prices on the last trading day than on the other trading days in the month. In other words, there is a statistically greater tendency for the last trading price in December to be a transaction price than for other trading days in December. Additionally, the last trading day in December is one of the five lowest non-trading days in ten of the last eighteen years.

We also examine the likelihood of a stock going without a trade for up to five consecutive days. We group firms into size decile portfolios. Overall, 2.24 percent of all stocks went untraded for two consecutive days; only 0.42 percent ever go untraded for five consecutive days. For the smallest size decile, over ten percent went untraded for two consecutive days, and over two percent remained without a trade for five consecutive days. These results are quite similar to Keim's (1989) results based on the turn-of-the-year. Based on the 1973 to 1990 period, we find the probability of a stock *not trading* conditional on a *non-trade* on the previous day is, on average, 37.6 percent, considerably greater than the unconditional probability of 6.0 percent. For the smallest (largest) size portfolio, the conditional probability is 45.7 (30.2) percent. The probability of a stock *not trading* conditional on a *trade* on the previous day is, on average, 4.6 percent and declines monotonically from the smallest portfolio (18.1 percent) to the largest portfolio (less than 0.02 percent).

C. Heterogeneity of Non-Trading Among Similar Stocks

The above sections examine average levels of non-trading. Although averages are useful in summarizing cross-portfolio and cross-time differences in the amount of non-trading, they do so at the expense of lost information about potential differences in non-trading among securities within a portfolio. To the extent that individual security non-trading is not homogeneous among otherwise-similar securities, summarization by means may be misleading and might result in potentially erroneous inferences about the impact of non-trading on measured portfolio returns. For example, a recent paper by Boudoukh, Richardson and Whitelaw (1993) argues that differences in the distribution of nontrading among securities in a portfolio can have a substantial influence on that portfolio's autocorrelation.

To examine the degree of heterogeneity in non-trading, Table III reports the fractiles of the distribution of percent non-trading for NYSE and AMEX stocks within each decile of size. We define percent nontrading as the ratio of the number of days a stock did not trade during a calendar year to the total number of trading days for that stock in that year. We compute this ratio for each

stock for each year. Using the values of non-trading for all stocks that appeared in a portfolio across all years from 1973 to 1990, we report distribution fractiles and means for each portfolio. The means, reported in the leftmost column in Table III, indicate the percentage of days within an average year that the "representative" stock in a portfolio did not trade. For example, the average stock in the smallest size decile did not trade on 31 percent of the trading days during an average year. The mean non-trading percentage declines almost monotonically with market capitalization to a value of 0.2 percent for the stocks in the decile of largest market cap.

Interestingly, the distribution fractiles indicate a substantial degree of heterogeneity in the amount of non-trading, particularly in the smaller market cap deciles. For example, while 10 percent of the stocks in the smallest decile trade virtually every day, 10 percent of the stocks in that decile do not trade on 51 percent of the trade days during the year, and one percent do not trade on 76 percent of the trade days during the year. Moreover, this cross-sectional heterogeneity does not vary much during the sample period. Figures 3a and 3b plot the year-by-year distributional fractiles for the two smallest market cap deciles. It is apparent from the figures that the non-trading heterogeneity reported in table III is not due to extreme levels of non-trading in only a small number of years.

II. An Application of the Non-trading Evidence

While our non-trading findings are interesting in their own right, the evidence in section I is useful for future research because it provides reasonable bounds for levels of nontrading. As an example, in this section we use our stylized facts from section I to reexamine the relation between stock return autocorrelations and non-trading. Previous research in this area relies primarily on *conjectures* about the extent of non-trading. Our contribution is to demonstrate the potential impact of non-trading on the measurement of return autocorrelations using *actual* non-trading levels.

A. Daily Portfolio Autocorrelations Implied by the Lo-MacKinlay Non-trading Model

A hypothesis, long conjectured by researchers, is that nonsynchronous or infrequent trading can result in significant small stock portfolio autocorrelations (e.g., Fisher (1966)). However, return-generating models that condition on non-trading have not been entirely successful in explaining autocorrelation patterns in actual returns. For example, Atchison, Butler and Simonds (1987) compare theoretical and observed daily index autocorrelations between 1978 and 1981 based on transaction-frequency data between January and March 1980. They find that a Scholes and

Williams (1977) model of nonsynchronous trading can explain only a small portion of the observed index autocorrelation over their period of study.

Lo and MacKinlay (1990a, 1990b) develop a general model of non-trading and examine the magnitude of index autocorrelations implied by the model.⁷ They derive expressions for moments of observed returns as a function of the non-trading process. In each period t there is a probability p_i that security i will not trade, and this probability is assumed to be iid. If a stock does not trade, then its observed return, $R_{i,t}^o$, is simply zero. If it trades the next period, then its observed return is simply the sum of $R_{i,t}^o$ and $R_{i,t+1}^o$. Within this framework, LM show that the autocorrelation for a portfolio 'a' can be calculated as:

$$\text{Corr} [R_{a-t}^o(q), R_a^o(q)] = \frac{(1-p_a^q)^2 p_a^{nq-q+1}}{q(1-p_a^2) - 2p_a(1-p_a^q)}, \quad (1)$$

where q represents the time aggregation interval (e.g., $q=1$ for daily returns, $q=5$ for weekly returns, etc.), n represents the number of lags and p_a represents a common (*homogeneous*) non-trading probability for portfolio 'a' securities. For daily returns, where $q=1$, equation (1) reduces to:

$$\text{Corr}[R_{a-n}^o, R_a^o] = p_a^n. \quad (2)$$

Note that the *first-order* (i.e., $n = 1$) autocorrelation for *daily* portfolio returns is simply the average non-trading probability for securities in that portfolio. Also note that with time aggregation (i.e., $q > 1$), even relatively large probabilities of daily non-trading will have a small impact on weekly and monthly autocorrelations.

We first reexamine the impact of non-trading on *daily* portfolio autocorrelations by computing implied values for portfolio autocorrelations as a function of the level of non-trading during the 1973-1990 period. Based on equation (2) and our estimates of average non-trading for

⁷As Lo and MacKinlay (1990a) indicate, the Scholes and Williams (1977) model requires each security to trade within a fixed time interval. It is worth noting that the Scholes and Williams empirical application attempts to eliminate securities that did not trade on a particular day, but their sample includes much of the 1964 to 1972 period during which CRSP omitted the information necessary to identify non-traded securities.

size portfolio deciles from Table III, the results are presented in Table IV. Average non-trading over the 1973 to 1990 period ranges from 0.2 percent for the largest decile portfolio to 31.0 percent for the smallest decile (see Table III). According to the model (equation (2)) the first-order autocorrelation equals the non-trading probability for the representative (average) security in the portfolio. We report the implied autocorrelation in the rightmost column of Table IV. We also report actual daily autocorrelations for value-weighted NYSE and AMEX size deciles over the 1973 to 1990 period in the first column, for comparison with the theoretically-implied values. Comparing the two columns, the daily autocorrelations implied by the model for the "representative" stocks in each portfolio uniformly underestimate the observed autocorrelations over this period.⁸

Inconsistent with the model's assumption of homogeneous nontrading among stocks in a portfolio, though, is the substantial heterogeneity of nontrading exhibited within each of the size deciles in table III. For example, 10 percent of the stocks in the smallest decile do not trade on more than 51 percent of all trading days, suggesting that the theoretically-implied autocorrelation for this group of stocks within the smallest size decile is substantially higher than that actually observed when measured for the entire decile of smallest stocks. Further, Boudoukh, Richardson and Whitelaw (1993) show that, given the kind of heterogeneity in the distribution of non-trading that we find here, the assumption of homogeneity is likely to underestimate the relation between return autocorrelation and nontrading. Further research is necessary to clarify these issues.

B. Daily Portfolio Return Autocorrelations and Non-trading: A Longer Perspective

Since the CRSP daily file begins in 1962, the source of reliable daily returns data for individual stocks is restricted to this more recent period. Hence, most studies focus on this period only. It is possible that the relation between non-trading and autocorrelation reported above is specific to the recent sample period. We investigate this possibility by examining the autocorrelation of the daily S&P Composite index, a series that is available back to 1928.⁹ The daily first-order autocorrelation for the S&P during the commonly-studied July 1962 to December

⁸The impact of non-trading on *weekly* and *monthly* autocorrelations is not presented in the table, but can be inferred from equation (1). For the smallest portfolio, the implied weekly and monthly first-order autocorrelations are 0.059 and 0.012, respectively, much lower than actual levels reported by Lo and MacKinlay (1990a) of 0.46 (weekly) and 0.20 (monthly) for their smallest portfolio.

⁹The pre-1962 segment of this series was compiled by Rob Stambaugh and is the same index used in Keim and Stambaugh (1984).

1990 period is 0.135. However, the estimated first-order daily autocorrelation for the January 1928 to June 1962 period is 0.038, approximately one-fourth as large as in the later subperiod. The estimate for the entire 1928-1990 period is 0.062.¹⁰ The time series behavior of the S&P autocorrelation is illustrated in figure 4 which displays the within-year estimates of autocorrelations based on daily returns for the S&P and within-year non-trading for NYSE stocks (compiled from the monthly data described above in section I) for the 1928-1990 period. The early period is interesting. From the 1920s through the early 1940s, a period when non-trading was at its highest levels during the century, the autocorrelations of the daily returns on the S&P were at the lowest levels of the century.¹¹ Whereas there is a positive relation between the S&P autocorrelation and the within-year non-trading in the 1962-1990 period (excluding 1964-1972), there is a significantly *negative* relation for the 1928-1962 period. These general observations for the longer time period are consistent with earlier studies suggesting that positive index autocorrelation is not solely attributable to infrequent trading.¹²

¹⁰Schwert (1990, Table 8) estimates the first-order serial correlation on a daily stock index series from 1885 to 1987 as 0.05.

¹¹The S&P Composite contained only 90 stocks during the period from 1928 to February 1957. It is unlikely, though, that this reduction in the number of securities is responsible for the low autocorrelation in the early period.

¹²Also of note is the decline of the daily S&P autocorrelations through the 1970's and 1980's. One possible explanation for this decline involves the relative proportions of institutional and individual investors in the market. The idea is that if institutional investors tend to trade more frequently in portfolios of stocks rather than individual stocks (e.g., program trading, indexing), then buys and sells across securities contained in their portfolios will have greater synchronousness. Further, to the extent that such investors are index funds and use "market at close" orders to permit closer alignment with their benchmark portfolios, these firms might influence the distribution of daily closing prices by causing clustering of prices at the bid or ask quotes. For example, if one of these firms were in the midst of a buying program, a larger percentage of transactions would occur closer to the market maker's ask price. A natural outcome is an increased tendency for *portfolio* bid-ask bounce. That is, the bid-ask bounce that is evident in individual security returns, but which is normally eliminated in diversified portfolios, will not be diversified. The resulting negative autocorrelation will tend to offset positive autocorrelation induced by positive cross-autocovariances (Lo and MacKinlay (1990b)). Other things equal, we should observe a reduction in portfolio autocorrelations since the introduction of such trading practices, especially for portfolios that are heavily concentrated in the stocks contained in such institutional portfolios. As a result, the period since (approximately) 1970, which displays a pattern of declining index autocorrelation (figure 4), may represent an institutionally-dominated regime distinct from the earlier period extending back to 1928. See Froot and Perold (1990) who also discuss similar arguments. Brenner, Subrahmanyam and Uno (1990) and Kishimoto (1990) find a similar decline in the daily autocorrelations of the

III. Conclusions

We document a declining pattern of non-trading over the 1926 to 1990 period. Frequency of non-trading is directly related to firm size. Non-trading occurs less frequently in December relative to other months, and this is particularly true for smaller firms. Since 1973, non-trading has averaged about 1.3 percent for NYSE firms, 15.1 percent for AMEX firms and 24.1 percent for NYSE and AMEX firms in the smallest size decile portfolio. Non-trading is shown to increase monotonically from Monday through Friday. Our analysis excludes the years 1964 to 1972 (inclusive) because of the abnormally low number of negative prices recorded by CRSP during that period. Any future research in the area of non-trading which relies on the CRSP tapes should bear this in mind.

We also find substantial heterogeneity in the amount of non-trading across the stocks within each size decile. For example, while 10 percent of the stocks in the smallest decile trade virtually every trade day, 10 percent of the stocks in that decile do not trade on 51 percent of the trade days during the year, and one percent do not trade on 76 percent of the trade days during the year. Further, this heterogeneity is prevalent in every year from 1973 to 1990, indicating that a large percentage of NYSE and AMEX stocks consistently exhibit substantial non-trading. These findings have important implications for inferences about return autocorrelations drawn from models of non-trading that assume homogeneous non-trading among similar (market-cap) stocks.

Finally, our results provide useful bounds for future studies relating to non-trading. In this vein, we present a simple application relating to the influence of non-trading on daily portfolio return autocorrelations. This application highlights the need for more research on the relation between non-trading and return autocorrelations.

Nikkei Stock Average and the Topix index after September 1988 when futures contracts on these indexes were introduced.

REFERENCES

- Atchison, M., K. Butler and R. Simonds, 1987, Nonsynchronous security trading and market index autocorrelation, *Journal of Finance* 42, 111-118.
- Blume, M. and R. Stambaugh, 1983, Biases in computed returns: An application to the size effect, *Journal of Financial Economics* 12, 387-404.
- Boudoukh, J., M. Richardson and R.F. Whitelaw, A tale of three schools: Insights on autocorrelations of short-horizon returns, working paper, Wharton.
- Brenner, M., M.G. Subrahmanyam and J. Uno, 1990, The volatility of the Japanese Stock Indices: Evidence from the cash and futures market, working paper, NYU.
- Cohen, K., G. Hawawini, S. Maier, R. Schwartz and D. Whitcomb, 1983, Frictions in the trading process and the estimation of systematic risk, *Journal of Financial Economics* 12, 263-278.
- Dimson, E., 1979, Risk measurement when shares are subject to infrequent trading, *Journal of Financial Economics* 7, 197- 226.
- Dimson, E. and P. Marsh, 1983, The stability of UK risk measures and the problem of thin trading, *Journal of Finance* 38, 753- 783.
- Fowler, D. and C. Rourke, 1983, Risk measurement when shares are subject to infrequent trading: Comment, *Journal of Financial Economics* 12, 279-283.
- Fama, E., 1965, Tomorrow on the New York Stock Exchange, *Journal of Business* 38, 285-299.
- Fisher, L., 1966, Some new stock market indices, *Journal of Business* 39, 191-225.
- Froot, K. and A. Perold, 1990, New trading practices and short-run market efficiency, NBER Working Paper No. 3498.
- Kaul, G. and M. Nimalendran, 1990, Price reversals: Bid-ask errors or market overreaction?, *Journal of Financial Economics* 28, 67-93.
- Keim, D., 1989, Trading patterns, bid-ask spreads and estimated security returns: The case of common stocks at calendar turning points, *Journal of Financial Economics*, 25, 75-97.
- Keim, D. and R. Stambaugh, 1984, A further investigation of the weekend effect in stock returns, *Journal of Finance* 39, 819-835.
- Kishimoto, K., 1990, A new approach for testing the randomness of heteroscedastic time-series data, working paper, University of Tsukuba.
- Lakonishok, J. and S. Smidt, 1984, Volume and turn-of-the-year behavior, *Journal of Financial*

- Economics* 13, 435-456.
- Lo, A., and A.C. MacKinlay, 1990a, An econometric analysis of nonsynchronous-trading, *Journal of Econometrics* 45, 181-211.
- Lo, A. and A.C. MacKinlay, 1990b, When are contrarian profits due to stock market overreaction?, *The Review of Financial Studies* 3, 175-205.
- Neiderhoffer, and Osborne, 1966, Market making and reversal on the stock exchange, *Journal of American Statistical Association* 61, 897-916.
- Porter, David C., 1992, The probability of a trade at the ask: An examination of interday and intraday behavior, *Journal of Financial and Quantitative Analysis* 27, 209-228.
- Perry, P., 1985, Portfolio serial correlation and nonsynchronous trading, *Journal of Financial and Quantitative Analysis* 20, 517-523.
- Scholes, M. and J. Williams, 1977, Estimating betas from nonsynchronous data, *Journal of Financial Economics* 5, 309- 327.
- Schwert, W., 1990, Indexes of U.S. stock prices, *Journal of Business* 63, 399-426.
- Stoll, H. and R. Whaley, 1990, Stock market structure and volatility, *The Review of Financial Studies* 3, 37-71.

Table I

**Frequency of non-trading measured by the average percent of negative prices at month-end as recorded
on the monthly CRSP file of NYSE stocks**

If a stock does not trade on the last trading day of the month, the CRSP monthly file reports the average of the bid and ask prices as a negative value. Portfolios of NYSE and AMEX stocks are ranked by year-end market value of equity. The sample period is 1926 to 1990. The sample excludes the years 1964-1972 because of the abnormally low number of negative prices recorded by CRSP during that period.

Size Decile	A. 1926-1990		B. 1926-1945			C. 1946-1963			D. 1973-1990		
	Mean	Median	Median	75%	Maximum	Median	75%	Maximum	Median	75%	Maximum
All Firms	14.2%	7.9%	23.4%			7.7%			0.9%		
Smallest	29.3	25.3	49.7	64.7	90.6	25.3	33.1	68.6	7.8	16.5	66.7
2	21.5	17.0	36.4	50.0	78.5	16.9	23.2	73.3	4.9	9.7	27.5
3	19.1	13.8	34.6	46.9	84.7	12.9	19.4	61.1	3.2	5.7	20.3
4	16.9	10.8	30.4	42.6	73.9	10.8	17.5	52.2	2.0	3.6	10.5
5	14.6	8.6	25.9	40.3	72.3	8.4	13.3	55.6	1.2	2.4	11.1
6	12.5	6.9	23.8	35.5	79.0	6.1	9.7	41.9	0.5	1.6	7.6
7	10.5	4.9	22.0	30.2	58.4	4.6	7.6	42.7	0.5	1.3	7.4
8	8.0	2.8	16.4	23.3	50.6	2.2	5.9	36.2	0.4	0.9	3.3
9	5.8	2.0	11.8	17.0	39.2	1.9	3.8	24.5	0.0	0.4	2.3
Largest	3.5	1.0	7.3	10.7	30.0	0.9	1.9	25.0	0.0	0.0	0.7

Table II

Frequency of non-trading measured by the mean percent of negative prices on each day as recorded on the daily CRSP file of NYSE and AMEX stocks

If a stock does not trade on a particular day, the CRSP daily file reports the average of the bid and ask prices as a negative value. Portfolios of NYSE and AMEX stocks are ranked by year-end market value of equity. The sample period is 1973 to 1990.

		All Stocks	NYSE Only	AMEX Only	Smallest Decile	Largest Decile
Day	Monday	5.74	1.28	15.12	23.44	0.18
	Tuesday	5.86	1.31	15.43	24.41	0.14
	Wednesday	6.04	1.38	15.85	24.83	0.15
	Thursday	6.26	1.46	16.37	25.59	0.15
	Friday	6.32	1.50	16.50	25.65	0.16
Month	January	5.67	1.22	15.09	24.50	0.15
	February	5.77	1.31	15.18	24.60	0.14
	March	5.69	1.29	14.98	23.78	0.14
	April	5.94	1.32	15.66	25.15	0.16
	May	6.20	1.41	16.32	25.90	0.15
	June	6.48	1.53	16.92	26.67	0.19
	July	6.47	1.50	16.95	27.24	0.18
	August	6.75	1.63	17.45	27.47	0.19
	September	6.68	1.59	17.35	26.71	0.17
	October	6.66	1.55	17.40	27.09	0.16
	November	6.00	1.37	15.77	23.37	0.14
	December	4.17	0.90	11.10	14.76	0.14
Year	1973	6.61	1.88	15.19	25.60	0.38
	1974	11.16	3.50	25.96	38.05	0.61
	1975	10.84	3.04	26.20	38.40	0.34
	1976	7.83	1.95	19.91	30.63	0.50
	1977	7.87	1.93	20.35	32.10	0.22
	1978	5.82	1.45	15.46	23.44	0.11
	1979	5.41	1.25	14.92	22.99	0.02
	1980	4.56	0.98	12.87	21.77	0.02
	1981	4.59	1.10	12.90	21.97	0.02
	1982	5.27	1.35	14.14	24.85	0.07
	1983	2.75	0.57	7.68	12.67	0.10
	1984	4.35	0.95	12.28	19.80	0.20
	1985	3.88	0.60	11.46	18.21	0.10
	1986	3.21	0.44	9.62	16.89	0.05
	1987	3.36	0.47	9.79	15.24	0.00
	1988	6.91	1.06	18.61	25.89	0.04
	1989	6.42	0.98	17.07	24.74	0.03
1990	7.98	1.46	21.08	33.01	0.00	
Overall		6.05	1.39	15.86	24.79	0.16

Table IV

Actual and model-implied daily autocorrelations
for NYSE and AMEX stocks for the 1973-1990 period

Market Cap Decile	Daily Autocorrelation	
	Actual	Implied ¹
Smallest	0.379	0.310
2	0.349	0.187
3	0.330	0.115
4	0.336	0.083
5	0.314	0.057
6	0.315	0.099
7	0.316	0.065
8	0.287	0.026
9	0.268	0.010
Largest	0.169	0.002

¹ 1st order autocorrelation implied by the Lo-MacKinlay non-trading model and the non-trading values from Table III

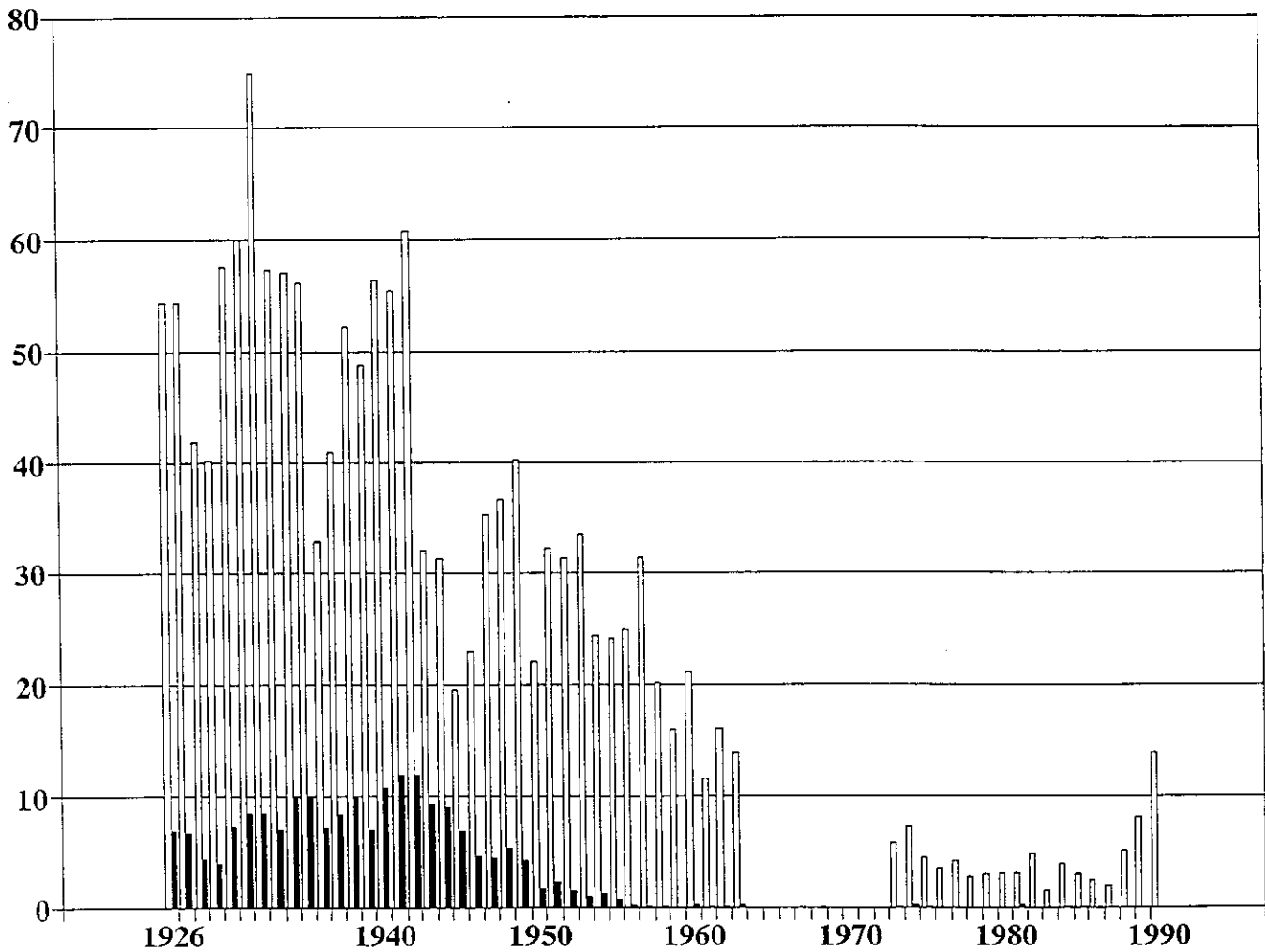


Figure 1. Frequency of non-trading of the smallest and largest portfolios of NYSE stocks. The smallest portfolio is represented by the white bars and the largest portfolio is represented by the black bars. If a stock does not trade on the last day of the month, the CRSP monthly file reports the average of the bid and ask prices as a negative value. Month-end frequencies of non-trading are averaged to create within-year frequencies. The sample period is 1926 to 1990.

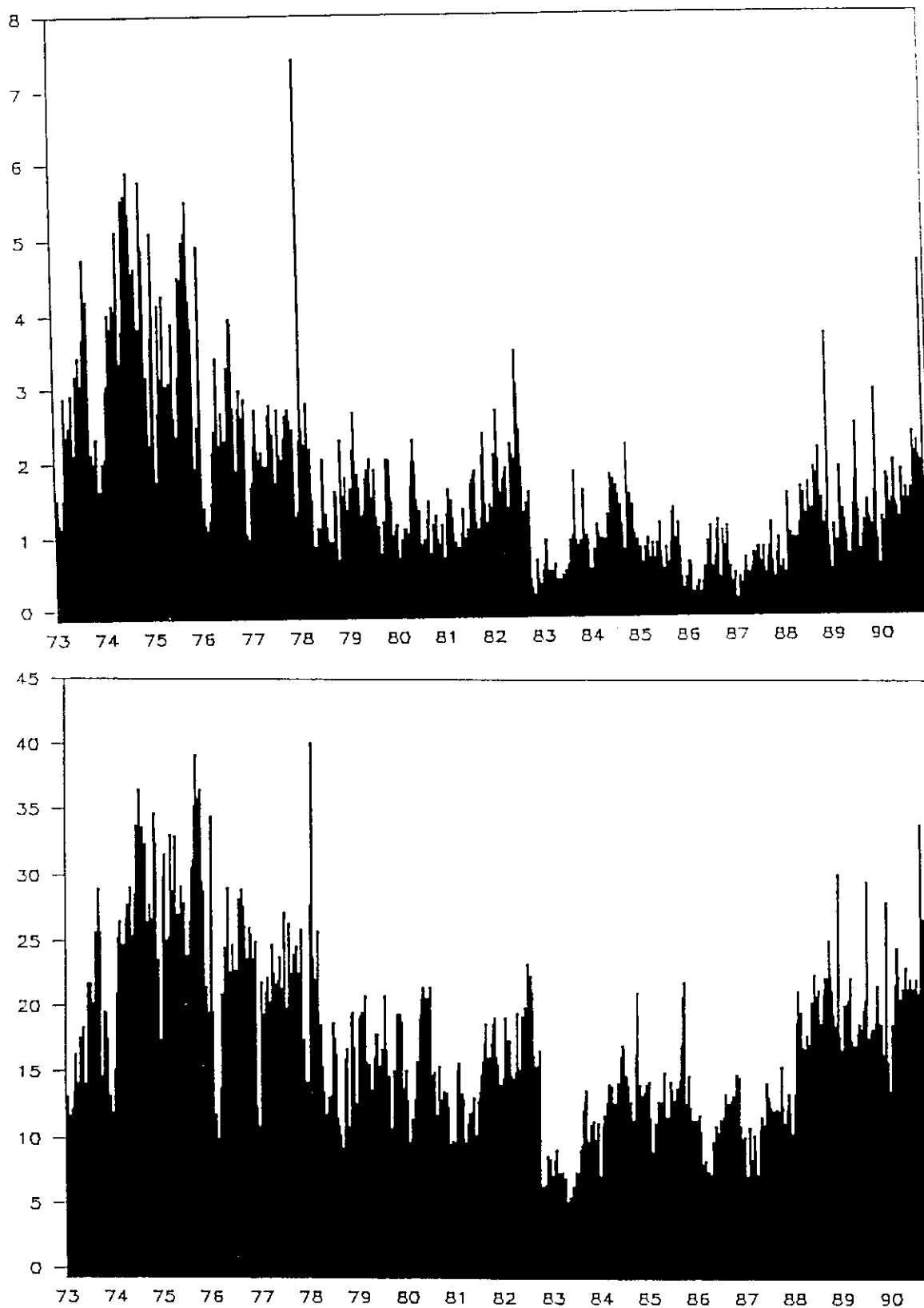


Figure 2. Frequency of non-trading of NYSE and AMEX stocks. The upper panel presents NYSE frequencies and the lower panel presents AMEX frequencies. If a stock does not trade a particular day, the CRSP daily file reports the average of the bid and ask prices as a negative value. The sample period is 1973 to 1990.

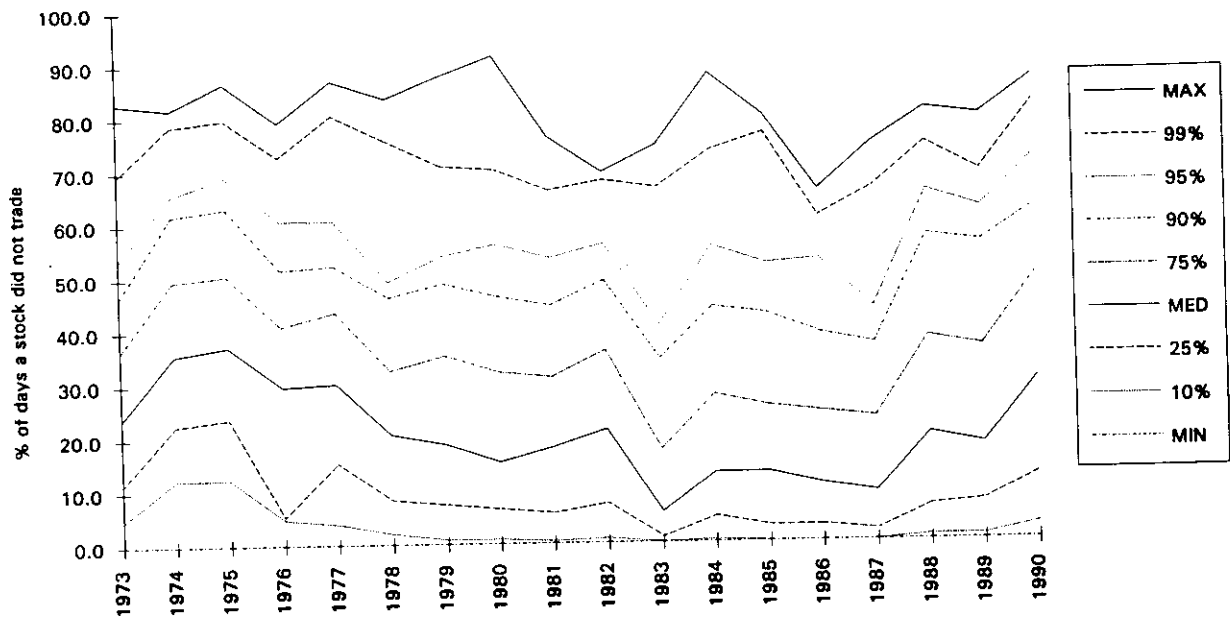


Figure 3a. Fractiles of the distribution of the number of non-traded days as a percentage of total trading days for the decile of smallest NYSE and AMEX stocks, measured within each year from 1973 to 1990. The non-trading percentage is measured for each stock in the smallest market cap decile at the beginning of each year as the ratio of the number of non-traded days to the total number of trading days during the year.

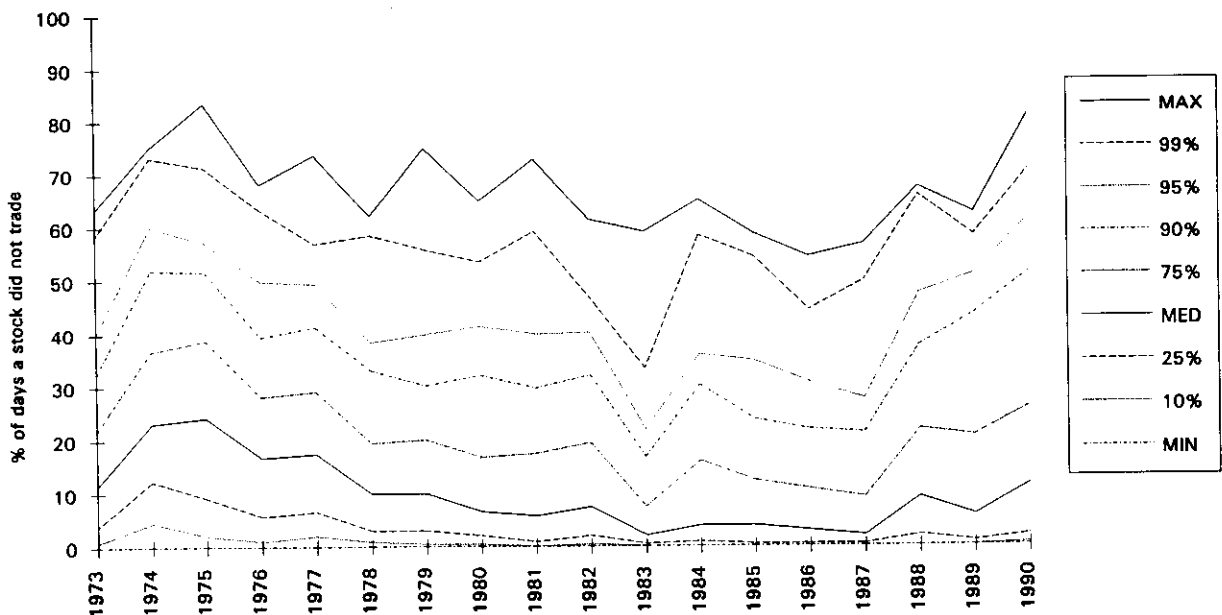


Figure 3b. Fractiles of the distribution of the number of non-traded days as a percentage of total trading days for the second (next to smallest) decile of NYSE and AMEX stocks, measured within each year from 1973 to 1990. The non-trading percentage is measured for each stock in the second decile at the beginning of each year as the ratio of the number of non-traded days to the total number of trading days during the year.

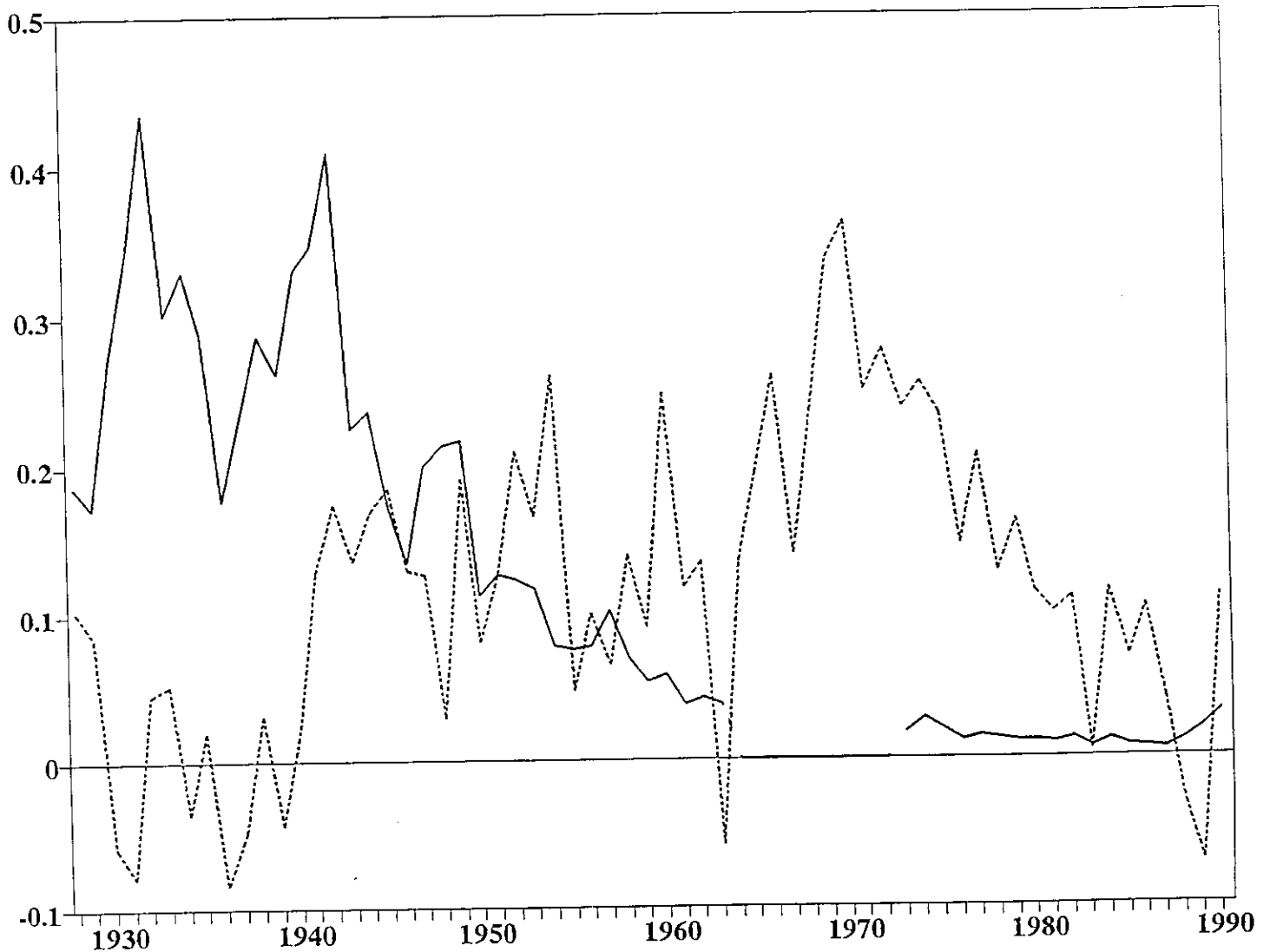


Figure 4. Frequency of non-trading NYSE stocks and daily autocorrelations for the S&P Index, measured within-years. The solid line represents the frequency of non-trading and the dotted line represents the daily autocorrelations. If a stock does not trade on the last day of the month, the CRSP monthly file reports the average of the bid and ask prices as a negative value. Month-end frequencies of non-trading are averaged to create within-year frequencies. The sample period is 1928 to 1990. The sample for non-trading frequencies excludes the years 1964-72 because of the abnormally low number of negative prices recorded by CRSP during that period.