G. William Schwert
University of Rochester and National Bureau of Economic Research

Indexes of U.S. Stock Prices from 1802 to 1987*

Monthly stock returns from Smith and Cole (1935), Macaulay (1938), and Cowles (1939) are compared and contrasted with the returns to the Center for Research in Security Prices (CRSP) value-weighted portfolios of New York Stock Exchange (NYSE) stocks. Daily stock returns from Dow Jones (1972) and Standard and Poor's (1986) are compared and contrasted with the returns to the CRSP value-weighted portfolios of NYSE and American Stock Exchange (AMEX) stocks. Effects of dividends, nonsynchronous trading, and time averaging are analyzed. Splicing together the best indexes gives monthly data from 1802–1987 (2,227 observations) and daily data from 1885–1987 (28,884 observations).

I. Introduction

It is widely recognized that the development of the monthly New York Stock Exchange (NYSE) stock return data base by the Center for Research in Security Prices (CRSP) at the University of Chicago spawned an explosion of empirical research in finance during the late 1960s and early 1970s. Papers such as Fama, Fisher, Jensen and Roll (1969), Blume (1971), Black, Jensen, and Scholes (1972), and Fama and MacBeth (1973) have accumulated several hundred citations each from subsequent papers in economics journals. As noted by Merton (1987), one of the unfortunate byproducts of this public good is that researchers have focused most of their attention on these data because of the relatively inexpensive high quality data provided by CRSP. The CRSP data base starts in 1926, just years before the Great Depression, the most severe economic contraction in United States history. There is evidence that the behavior of stock market volatility and stock returns was unusual in the 1929–39 decade, so empirical tests that include these data are suspect. For example,

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Schwert (1989*a*) argues that the standard deviation of monthly stock market returns rose more during the Depression than can be explained by the increase in the volatility of other economic variables. Fama and French (1988*a*), Kim, Nelson, and Startz (1988), and Poterba and Summers (1988) show that the long-term negative autocorrelation of stock returns is heavily influenced by the 1929–39 data.

Because of the recent interest in long-run behavior of stock returns, and the realization that the Great Depression may be anomalous,[1] there has been a renewed interest in the behavior of pre-CRSP stock return data. For example, Wilson and Jones (1987) use a slightly corrected version of the Cowles (1939) stock market return series to replicate the Ibbotson and Sinquefield (1976) study of stock, bond, and bill returns and inflation for 1871–1925. Schwert (1989*a*, 1989*b*) and Pagan and Schwert (1990) study monthly volatility of stock return data from Smith and Cole (1935), Macaulay (1938), and Cowles (1939). Schwert (1990) studies the behavior of daily stock returns and volatility from February 1885 through 1987, using the Dow Jones portfolios from 1885 to 1927 and the Standard and Poor's composite portfolio from 1928 to 1987.

This article compares and contrasts all the major indexes of stock prices or returns that are available monthly from 1802 to 1925 or daily from 1885 to 1962. The outcome of this comparison is a series of monthly stock portfolio returns from 1802 to 1925 and daily returns from 1885 to 1962 that come closest to the CRSP value-weighted portfolio.

Section II contains a brief description of early stock price or return indexes, including a description of the measurement process for individual stock prices, the method of weighting used to create the index, and the treatment of dividends. Perhaps the broadest portfolios of pre-1925 stocks, and the only one that includes dividends, is the series by Cowles (1939). Unfortunately, the Cowles data use the averages of high and low prices in the month for individual stocks. This form of time aggregation has effects similar to the analysis of Working (1960). To document the effects of this measurement process, Section III analyzes a Cowles-type portfolio created from the CRSP data base of daily stock prices and returns for all NYSE and American Stock Exchange (AMEX) stocks. Section IV describes the methods used to combine the various indexes into a continuous series of monthly returns from 1802 to 1987, and a continuous series of daily returns from 1885 to 1987. Section V analyzes the statistical properties of the best spliced portfolio of monthly stock returns from 1802 to 1987 and the best spliced portfolio of daily stock returns from 1885 to 1987. It shows the effects

1. It is worth noting that macroeconomists have devoted much effort to studying the unusual behavior of economic aggregates during the Great Depression. It is arguable that the creation and popularity of Keynesian economics was largely due to these empirical anomalies.

of time aggregation and of omitting dividend yields. It also analyzes daily and monthly seasonal effects in returns. Section VI contains brief conclusions.

II. Early Stock Price Indexes

A. *The Smith and Cole Indexes of Bank, Insurance, and Railroad Stock Prices*

Smith and Cole (1935) summarized much of the early work on stock price indexes by the Harvard Economic Society (see Persons, Tuttle, and Frickey 1920, Matthews 1926, and Cole and Frickey 1928). They created several indexes for various periods from 1802 to 1860. From 1802 through 1820 (table 61, p. 173), they construct an equal-weighted portfolio of seven bank stocks in Boston, New York, and Philadelphia. The price quotations came from local newspapers, and they often were averages of bid and ask prices, rather than transactions prices. From 1815 through 1845 (table 62, p. 174), they created an equal-weighted portfolio of six New York banks and one insurance stock. For both of these portfolios, Smith and Cole omitted most of the stocks for which they had collected price data. They chose stocks in hindsight to represent typical movements in the period. The sample selection bias caused by only including stocks that survived and were actively quoted for the whole period is obvious.

From 1834 through 1845 (table 69, p. 183) and 1843 through 1862 (table 70, p. 184), Smith and Cole constructed an equal-weighted portfolio of all railroad stocks for which a rate of return could be calculated. At most, 27 stocks are in the portfolio, and they are split between New England and the Central Atlantic regions. In the period of overlap, these indexes differ only by rounding error.

It is unclear at what time in the month Smith and Cole collected stock prices, but they did use point-sampled prices rather than time-averaged prices (i.e., they used one price per month per stock instead of an average of several prices in the month). This is important in analyzing the autocorrelation of monthly returns or the volatility of returns.

Smith and Cole used equal-weighted portfolios of stock prices. They did not measure dividend payments. Thus, the portfolio return R_{pt} for N stocks is

$$R_{pt} = \sum_{i=1}^{N} w_i R_{it}, \quad w_i = 1/N, \tag{1}$$

$$R_{it} = (p_{it}/p_{it-1}) - 1, \tag{2}$$

where p_{it} is the price of stock i in month t.

B. The Macaulay Index of Railroad Stock Prices

Macaulay (1938) created an index of railroad stock prices from January 1857 through December 1938. His rationale for focusing on railroad stocks was that railroads were essentially the only nonfinancial stocks actively traded from 1857 through 1909 (Macaulay 1938, pp. 138–39), and he wanted to maintain a comparable portfolio throughout his sample. It is unclear what sources Macaulay used to collect individual stock prices, but he included all railroads with actively traded stocks. The number of stocks in the index varied from about 25 to about 50, being lowest in the early part of the sample. Most of the railroads were in the Northeast and mid-Atlantic regions.

It is not clear when during the month Macaulay measured prices, although the subsequent statistical analysis shows that he must have used time-averaged price data. He used a value-weighted portfolio of stocks to create his index number, and he did not measure dividend payments. Thus, the portfolio return R_{pt} for N stocks is

$$R_{pt} = \sum_{i=1}^{N} w_{it}R_{it}, \quad w_{it} = (p_{it-1}\, q_{it-1}) \Big/ \left(\sum_{i=1}^{N} p_{it-1}\, q_{it-1} \right), \tag{3}$$

where individual stock returns are measured as in (2), and q_{it-1} is the number of shares outstanding at the beginning of the month.

C. The Cowles Index of NYSE Stock Prices and Dividends

Cowles (1939) was the largest effort to collect nineteenth-century stock return data. His aggregate index included all NYSE-listed stocks whose prices were reported in the *Commercial and Financial Chronicle* during a month. In addition, Cowles is the only researcher to measure dividend payments so a total rate of return can be measured. As shown below, this is most important for judging the level of average returns to stocks. It is much less important for judging the autocorrelation or volatility of stock returns. Besides his aggregate index, Cowles created 68 industry indexes. The Cowles data cover the January 1871–December 1938 period. From 1918 to 1938, Cowles used the Standard and Poor's (S&P) industrial portfolios. He used Macaulay's index for his railroad industry portfolio.

Cowles used a value-weighted portfolio of stocks to create his index number. He created both price and total-return indexes. Thus, the portfolio return including dividends for N stocks uses (3), and returns are calculated as

$$R_{it} = [(p_{it} + d_{it})/(p_{it-1})] - 1, \tag{4}$$

where d_{it} is the dividend payment per share to stock i in month t. The number of stocks in the Cowles index varied from 12 (in 1871) to 351 (in 1938).

As mentioned in the introduction, the biggest problem with the

Cowles data, relative to the CRSP value-weighted portfolio, is that the price of a stock was measured as the aveage of the high and low prices in the month, rather than the last trade (closing price) in the month. This problem occurred because the primary data source was the *Commercial and Financial Chronicle,* which only reported high and low prices. For the data after 1918, a similar problem exists since the monthly Standard and Poor's indexes are averages of the weekly values in the month. Section IV documents the effects of using such time-averaged data.

D. *The Dow Jones Indexes of NYSE Stock Prices*

Beginning February 16, 1885, to the present, Dow Jones (1972) has reported daily indexes of from 12 to 50 industrial and transportation stock prices. The composition of the index has changed many times, but the goal has been to include the stocks that were most important in trading activity or capitalization. The index numbers are price weighted and they do not include dividends, so portfolio returns are calculated using

$$R_{pt} = \sum_{i=1}^{N} w_{it}R_{it}, \quad w_{it} = \left(p_{it-1} \Big/ \sum_{i=1}^{N} p_{it-1}\right), \tag{5}$$

and returns are calculated using (2). From 1885 to 1896, Dow Jones calculated one index that was dominated by railroad stocks but included a few industrials. From 1897 to the present, they report separate indexes for transportation and industrial stocks. I combine these indexes to create a composite index weighting each subindex in proportion to the number of stocks in each portfolio (e.g., 60% weight on the 30 industrials and 40% weight on the 20 transportation stocks since October 1928).

E. *S&P Composite Index*

From January 1928 through February 1957, Standard and Poor's (1986) reported a daily value-weighted index of 90 prominent NYSE common stocks. In March 1957, the coverage of the index expanded to 500 stocks. These indexes do not include dividends, so portfolio returns are measured using (3) and (2).

The monthly S&P composite index that is often published in government statistics sources is not the S&P composite index for the last day of the month. Instead, it is an average of the daily index values in the month. Thus, the time-aggregation problem mentioned above is a problem for this monthly S&P series.

III. The "Working Effect" in the Cowles Index

Working (1960) analyzed the effect of time-averaging data that come from a random walk. For example, if the daily S&P composite index follows a random walk, and the monthly S&P index is an average of the daily values in the month, Working's analysis implies that the monthly S&P series would follow an integrated moving average process of order 1 (IMA(1,1)).[2] The autocorrelation of the changes in the index (or the returns) should be about .25 at lag 1, and 0 at higher lags. The process of averaging the high and low prices for the month, used by Cowles (1939), is similar to time averaging. It is unlikely that these prices occur close to each other in calendar time. Besides first-order autocorrelation of returns, time averaging reduces the variance of returns by about 20%.

To gauge the seriousness of this problem, I performed the following experiment (suggested by Michael Barclay). Using the CRSP data base of daily stock prices and returns from July 1962 through December 1986, I calculated the average of the high and low closing prices for the days in the month for each stock on the NYSE and AMEX. Then I calculated the return on an equal-weighted portfolio using these "Cowles" prices.

Table 1 compares the sample mean (mean), standard deviation (SD), skewness (skew), excess kurtosis (kurt), studentized range (SR),[3] 3 autocorrelations and cross-correlations of the simulated Cowles returns with the CRSP equal-weighted portfolio of NYSE and AMEX stocks based on end-of-month prices. As predicted, the simulated Cowles returns have a large positive autocorrelation at lag 1 (.28), and the standard deviation is 24% lower than for the CRSP series. Thus, using average of high and low prices in the month makes the Cowles returns more persistent and less volatile than if end-of-month prices are used.[4] Moreover, the correlation between the CRSP return in month t and the Cowles return in the following month (.58) is almost as large as the correlation in the current month (.69). Thus, the time-averaged return series lags the point-sampled return series.

IV. Combining Different Indexes to Create Continuous Series

A. *Methodological Issues*

There are several ways that different series of stock returns could be combined to create a continuous series of market returns. First, a simple strategy is to choose the index that is "best" for each period. Of

2. See Box and Jenkins (1976) for a description of the autoregressive integrated moving average (ARIMA) processes. For a related analysis of the effects of nonsynchronous measurement of individual stock returns on portfolio returns, see Lo and MacKinlay (1990).

3. David, Hartley, and Pearson (1954) describe the use of the range divided by the standard deviation as a test for nonnormality or heteroscedasticity.

4. See Wilson, Jones, and Sylla (1988) for a related analysis of the Cowles return series.

TABLE 1 **Comparison of CRSP Equal-weighted Point-sampled Monthly Return to NYSE and AMEX Stocks versus Simulated "Cowles-Type" Monthly Returns, and Cowles Returns Filtered to Correct for Time Averaging, 1962–86**

First Series, $r1$, Second Series, $r2$	Sample Period (N)	Mean	SD	Skewness	Excess Kurtosis	Studentized Range	Autocorrelation at Lag			Cross-Correlations at Lag k, corr($r1(t)$, $r2(t+k)$)						
							1	2	3	+3	+2	+1	0	−1	−2	−3
CRSP	1962–86 (291)	.0095	.0429	.09	.93	6.63	.01	−.02	.03							
vs.										.04	−.03	.58	.69	.00	−.02	.05
Cowles		.0082	.0348	−.40	.90	6.56	.28	.00	.04							
vs.										.09	−.15	.38	.72	.01	−.03	.03
corrected Cowles*		.0082	.0418	−.24	1.34	7.01	−.01	−.01	.04							

NOTE.—The CRSP Daily Returns file from the University of Chicago is used to calculate monthly return series to equal-weighted portfolios of NYSE and AMEX stocks using the last price in the month (CRSP) and using an average of the highest and the lowest daily prices within the month (Cowles). Excess kurtosis should be zero for a normal distribution. The studentized range is the sample range divided by the sample standard deviation. See David, Hartley, and Pearson (1954). The cross-correlation at lag k measures the correlation of the return $r1$ at time t with the return $r2$ at time $t+k$.

* The corrected Cowles series is $\hat{R}_t = \hat{\mu} + \hat{\epsilon}_t[1.2(1 + \hat{\theta})^{1/2}]$, where $\hat{\mu} = .008226$ and $\hat{\theta} = -.3232$ are estimates of the parameters of the first-order moving average process for the Cowles return (eq. [6] in the text).

course, to use this strategy one must decide which criterion to use in choosing the best index. For example, it could be (*a*) a broad coverage of underlying stocks; (*b*) an appealing weighting method for the portfolio, such as value weights; (*c*) point-sampled, end-of-month price measurement for individual stocks, including dividends, or (*d*) some combination of these factors. As will be shown below, when measuring average returns, including dividends is important. Alternatively, when measuring stock-return volatility or autocorrelations, the use of point-sampled, rather than time-averaged, prices is important.

A more complex strategy would involve adjusting the best returns series for any known limitations. For example, one could estimate the unmeasured dividend yield and add it back into returns that do not include dividends. Schwert (1989*a*, 1989*b*) follows this strategy by estimating the dividend yield to the Macaulay (1938) and Smith and Cole (1935) indexes, using the average dividend yield to the Cowles (1939) index from 1871 to 1879.

B. Univariate Corrections for the Effects of Time Averaging

A correction for the effects of time averaging is not easy. This is a signal extraction problem, where the true (point-sampled) return is measured with serially correlated error. A univariate method to eliminate serial correlation of returns is to estimate a first-order moving average process,

$$R_t = \mu + \epsilon_t - \theta\epsilon_{t-1}, \qquad (6)$$

where the moving average parameter θ should be about $-.3$ (since the first-order autocorrelation from a MA(1) process is $-\theta/(1 + \theta^2) = .3/1.09 = .27$). The estimate of the point-sampled return is $\hat{R}_t = \hat{\mu} + \hat{\epsilon}_t$, which has the same mean μ as the original data R_t, but no first-order autocorrelation. Unfortunately, the variance of $\hat{R}_t$, which is the variance of $\hat{\epsilon}_t$, is less than the variance of the original data, $(\text{var}(\hat{R}_t) = \text{var}(R_t)/(1 + \theta^2))$. The analysis in Section III shows that time averaging reduces the variance of R_t relative to $\hat{R}_t$. This problem can be solved by multiplying the errors $\hat{\epsilon}$ by a constant $[1.2(1 + \theta^2)^{1/2}]$, so the standard deviation of the estimated returns is 20% larger than the standard deviation of the raw data, as predicted by Section III. Thus, the filtered return estimate is

$$\hat{R}_t = \hat{\mu} + \hat{\epsilon}_t[1.2(1 + \hat{\theta}^2)^{1/2}], \qquad (7)$$

where the parameters $\hat{\mu}$ and $\hat{\theta}$ and the residuals $\hat{\epsilon}_t$ are from (6).

Unfortunately, while this procedure corrects the mean, variance, and autocorrelations, it does not accommodate cross-correlations with other stock returns. Table 1 contains sample moments and autocorrelations for the "corrected Cowles" returns $\hat{R}_t$. It also shows cross-correlations of these series with the returns to point-sampled CRSP equal-weighted portfolio. Comparing the sample moments and autocorrelations for the filtered data $\hat{R}_t$ in table 1 with the estimates for the raw data R_t, the corrections in (7) achieve their goal. The standard deviation of $\hat{R}_t$ is about 20% larger than for the raw returns R_t, and the first-order autocorrelation is about .25 lower. All the other statistics are similar.

Unfortunately, the cross-correlations in table 1 show large correlation between the CRSP equal-weighted return in month t and the filtered Cowles returns in month $t+1$. Compared with the unfiltered Cowles return, the contemporaneous correlation is larger (.72 vs. .69) and the lagged correlation is smaller (.38 vs. .58), but it is still large. Thus, one must conclude that the filter in (7) does not completely solve the time-averaging problem.

Using the analogy with signal extraction, it is possible to use a Kalman filter to derive the minimum mean square error estimate of the point-sampled data (see Harvey and Pierse 1984). Unfortunately, the time series behavior of the Kalman filter estimates will be nothing like the behavior of the actual point-sampled returns (if they could be observed). The estimates will be smoother, with lower variability and positive autocorrelation. Thus, the "optimal" statistical method for correcting the effects of time averaging yields estimates of returns that are unattractive.

C. Estimating Dividend Yields

Many of the stock indexes measured only price changes. As shown below, the main effect of ignoring dividend yields is to lower estimates of mean returns. Table 2 contains sample moments, autocorrelations, and cross-correlations of monthly dividend yields for the Cowles portfolio from 1871 to 1938, and for the CRSP value-weighted portfolio of NYSE stocks from 1926 to 1987. The dividend yield δ_t is the difference between the total return and the capital gain return in month t:

$$\delta_t = R_t - [(P_t - P_{t-1})/P_{t-1}] = d_t/P_{t-1}, \qquad (8)$$

where d_t is the cash dividend paid on a portfolio with a price of P_{t-1} at the beginning of the period.

The average level of dividend yields is about .4 percent per month and the standard deviation of yields is small compared with the standard deviation of percent price changes. Yields are positively autocorrelated and there is a strong seasonal pattern shown by the large positive autocorrelations at lags 3, 6, 9, and 12. There is a large positive correlation between the CRSP value-weighted yield in month t and the Cowles yield in month $t + 1$. This probably reflects the effects of time averaging in the Cowles series.

TABLE 2 **Comparison of Monthly Dividend Yields to the Cowles (1939) and CRSP Value-weighted Portfolios**

A. Sample Moments for Full Sample Periods

Series	Sample Period (*N*)	Mean	SD	Skewness	Excess Kurtosis	Studentized Range	Autocorrelation at Lag 1	2	3	4	5	6	7	8	9	10	11	12
Cowles	1871–1938 (815)	.0042	.0021	1.08	2.06	6.76	−.11	−.06	.52	−.07	−.01	.59	−.04	−.05	.47	−.10	−.01	.59
CRSP VW	1926–87 (744)	.0038	.0023	1.08	1.62	6.90	−.15	−.20	.82	−.20	−.19	.83	−.20	−.20	.78	−.24	−.17	.89

B. Cross-Correlations between Dividend Yield Series for Overlapping Samples

First Series, $y1$, Second Series, $y2$	Sample Period (*N*)	Cross-Correlations at Lag k, corr($y1(t)$, $y2(t+k)$) +3	+2	+1	0	−1	−2	−3
Cowles vs. CRSP VW	1926–38 (156)	.32	.38	−.45	.54	.62	−.43	.35

NOTE.—Sample moments are calculated for monthly dividend yields for which data are available. Excess kurtosis should be zero for a normal distribution. The studentized range is the sample range divided by the sample standard deviation. See David, Hartley, and Pearson (1954). The cross-correlation at lag k measures the correlation of the yield $y1$ at time t with the yield $y2$ at time $t+k$.

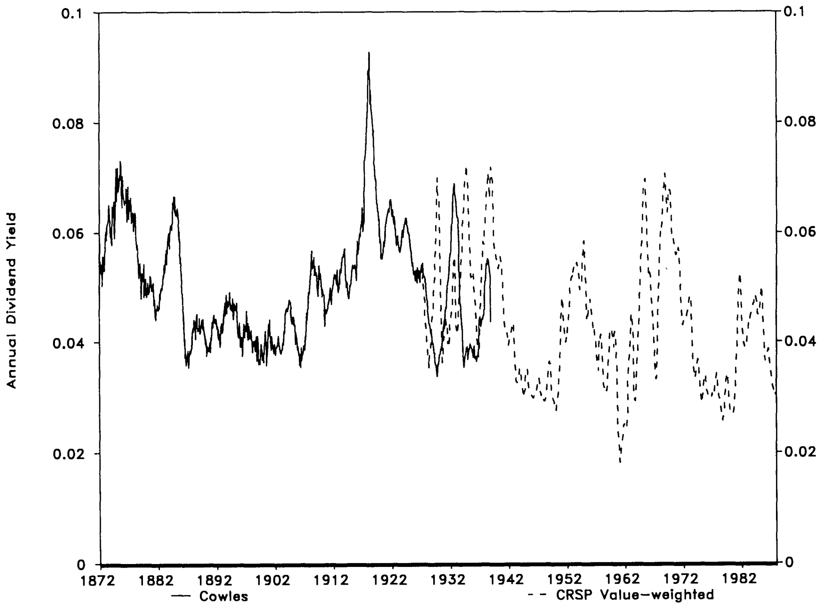

FIG. 1.—Estimates of annual dividend yields for the Cowles and CRSP value-weighted portfolios based on the last 12 monthly yields, 1872–1987.

Figure 1 shows a plot of monthly dividend yields for the Cowles and CRSP value-weighted portfolios from 1871 to 1987. These are the 12-month rolling sums of the monthly dividend yield series. From 1926 to 1938, both the Cowles and CRSP yields are available. It is clear from this plot that the Cowles and CRSP series are similar, so it is reasonable to splice the two series at the beginning of 1926 when the CRSP data begins.

From figure 1 there is no evidence of a secular change in the level of dividend yields. Schwartz (1960) presents estimates of corporate dividend payments for several dates between 1835 and 1871, which imply that yields on railroad stocks were not unusually high or low in this period. Otherwise, I could find no evidence on the size of yields before 1871. Macaulay's short-term commercial paper rates were as high or higher before 1857 as after. Also, his long-term railroad bond yields from 1857 to 1870 are not much different from the bond yields after 1871. Thus, there is reason to believe that dividend yields before 1871 were similar to those measured after 1871.

Fama and French (1988*b*) and Campbell and Shiller (1988) show that dividend yields are related to capital gain returns. Thus, it is of interest to see whether the percentage stock price changes available from 1802 to 1870 can be used to estimate the unmeasured dividend yields δ_t.

TABLE 3 **Estimates of Monthly Dividend Yields to the Cowles Portfolios and to the CRSP Value-weighted Portfolio Using Different Monthly Intercepts and 3 Leads and Lags of Monthly Capital Gain Returns**

$$\delta_t = \sum_{m=1}^{12} \mu_m + \sum_{k=-3}^{3} \alpha_k R_{t-k} + u_t \quad (9)$$

Coefficient	Cowles, 1871–1938	t-Statistic	CRSP VW 1926–87	t-Statistic
Differential intercepts:				
January, μ_1	.0051	17.68	.0017	25.54
February, μ_2	.0033	18.05	.0054	32.11
March, μ_3	.0041	16.58	.0035	19.90
April, μ_4	.0045	20.83	.0017	22.68
May, μ_5	.0033	14.00	.0056	33.23
June, μ_6	.0048	22.13	.0036	18.55
July, μ_7	.0053	21.01	.0017	24.43
August, μ_8	.0032	20.58	.0056	29.29
September, μ_9	.0040	17.51	.0033	18.76
October, μ_{10}	.0048	17.36	.0020	20.92
November, μ_{11}	.0030	19.45	.0073	22.47
December, μ_{12}	.0054	19.20	.0042	14.52
Coefficients of lead and lag stock price changes:				
α_{-3}	−.0023	−1.74	−.0002	−.24
α_{-2}	.0033	2.14	.0015	1.43
α_{-1}	−.0018	−1.19	.0020	1.96
α_0	−.0028	−2.00	−.0007	−.76
α_1	−.0006	−.32	−.0030	−2.75
α_2	−.0041	−2.49	−.0008	−.71
α_3	−.0045	−2.87	−.0043	−4.72

NOTE.—The dividend yield for month t, $\delta_t = d_t/P_{t-1}$, is regressed against 12 dummy variables representing different monthly intercepts, μ_m, and 3 leads and lags of the capital gain return, $R_{t-k} = (P_{t-k} - P_{t-k-1})/P_{t-k-1}$. t-statistics use White's (1980) heteroscedasticity consistent standard errors.

Table 3 contains estimates of the regression

$$\delta_t = \sum_{m=1}^{12} \mu_m + \sum_{k=-3}^{3} \alpha_k R_{t-k} + u_t, \quad (9)$$

where R_{t-k} is the capital gain return in month $t-k$ and μ_m represents the average dividend yield in month m. For the Cowles yields from 1871 to 1938, there is some variation in the level of average dividend yields across months, between .3% and .54% per month. There is a strong negative relation between past price changes ($k = 2$ and 3) and current dividend yields. This would occur if new information affects stock prices faster than dividend payments. A similar pattern occurs in the estimates for the CRSP value-weighted dividend yields from 1926 to 1987, except the seasonal pattern is even more pronounced. To forecast dividend yields for the period 1802–70, I use the estimates from the Cowles yields since they are closest in time to the period when the data are unavailable.

D. Splicing Monthly Data

From 1802 to 1814, the Smith and Cole (1935, table 61) bank stocks portfolio is the only choice available. From 1815 to 1820, Smith and Cole (1935, tables 61 and 62) provide nonoverlapping portfolios of bank and insurance stocks. A simple average of these returns is equivalent to an equal-weighted portfolio for the combined set of 14 stocks. From 1820 to 1833, the Smith and Cole (1935, table 62) portfolio of bank and insurance stocks is the only choice available. From 1834 to 1845, the Smith and Cole (1935, tables 62 and 69) portfolios of bank and insurance and railroad stocks are available. Table 4 compares these series for the period of overlap. The most notable difference is the much lower standard deviation of the bank stock returns. Since there are 27 stocks in the railroad portfolio, and only 7 in the bank and insurance portfolio, I use a weighted average of these returns with weights proportional to the number of stocks in the portfolio. This results in an equal-weighted portfolio of all the available stocks. From 1846 to 1856, the Smith and Cole (1935, table 70) railroad portfolio is the only choice available.

From 1857 to 1862, there is a choice between the Smith and Cole (1935, table 70) and the Macaulay (1938, table 10) portfolios of railroad stocks. Both portfolios use a similar set of stocks. Smith and Cole used equal weights, while Macaulay used value weights. Table 4 compares these series for the period of overlap. The main difference between these series is that the Smith and Cole returns have a higher standard deviation, and they have a large correlation with the previous month's Macaulay returns. The large cross-correlation is typical in comparing point-sampled returns with time-averaged returns. Conversely, the first-order autocorrelation for the Smith and Cole returns is lower than for the Macaulay returns, and the standard deviation is higher, both of which show that time averaging is a more serious problem for the Macaulay returns. This suggests that the Smith and Cole returns are not time averaged, but that the smaller railroad stock prices moved after the large ones in this turbulent period.

The period 1857–62 includes a major banking panic and recession in 1857 and the beginning of the Civil War. Comparing the standard deviation of the Smith and Cole railroad portfolio for 1843–62 (.0518) with its standard deviation for the 1857–62 subperiod in table 4 (.0731) shows that stock returns were much more volatile from 1857 to 1862. Conversely, if one were to splice the Macaulay returns to the Smith and Cole returns in 1857, the increase in volatility would be masked by the different portfolio weights and the use of time-averaged data. Thus, I use the Smith and Cole returns for this period.

TABLE 4 Comparison of Smith and Cole (1935) and Macaulay (1938) Monthly Portfolio Returns

First Series, $r1$ Second Series, $r2$	Sample Period (N)	Mean	SD	Skewness	Excess Kurtosis	Studentized Range	Autocorrelation at Lag			Cross-Correlations at Lag k corr($r1(t)$, $r2(t+k)$)						
							1	2	3	+3	+2	+1	0	−1	−2	−3
SC(62)	1834–45 (143)	−.0001	.0278	−.92	7.19	9.06	.30	−.10	−.15							
vs.										−.01	−.03	.18	.52	.23	.00	−.14
SC(69)		.0026	.0508	.46	1.04	6.37	.21	−.08	.01							
SC(70)	1857–62 (71)	.0056	.0731	−.75	2.34	5.79	.13	−.13	.09							
vs.										.12	−.06	−.09	.69	.66	−.06	−.02
Macaulay		.0027	.0502	−.43	1.92	5.87	.24	−.09	.00							

NOTE.—Sample moments are calculated for monthly stock returns for the period of overlap. Excess kurtosis should be zero for a normal distribution. The studentized range is the sample range divided by the sample standard deviation. See David, Hartley, and Pearson (1954). The cross-correlation at lag k measures the correlation of the return $r1$ at time t with the return $r2$ at time $t+k$.

The Macaulay (1938, table 10) portfolio of railroad stocks is the only choice available for 1863–70. When using the Macaulay or Cowles returns, I use the filtered estimates from (7) to correct for the time-averaging problem. All the returns from 1802 to 1870 omit dividend yields. I use the forecasts from (9) to estimate monthly dividend yields for 1802–70. Thus, the total return series is the sum of the capital gain returns from the price indexes, plus the estimated dividend yields:

$$R_t = \frac{(P_t - P_{t-1})}{P_{t-1}} + \frac{d_t}{P_{t-1}}. \tag{10}$$

For 1871–85, either the Macaulay or the Cowles (1939, tables P-1 or C-1) returns can be used. Since the Macaulay portfolio is a subset of the Cowles portfolio, and the Cowles series C-1 includes dividends, the Cowles series is preferred.

For 1885–1925, the Macaulay (1938, table 10), Cowles (1939, table P-1 or C-1), or the Dow Jones (1972) portfolio can be used. As before, the Cowles returns dominate the Macaulay returns. The Dow Jones portfolio is smaller than the Cowles portfolio, and it is price weighted rather than value weighted. Nevertheless, since it uses end-of-month prices, it is probably preferable to the Cowles portfolio that uses time-averaged prices. Thus, for March 1885 through the end of 1925, I use the percent price change for the Dow Jones portfolio plus the dividend yield from the Cowles portfolio. From 1926 to 1987, I use the CRSP value-weighted portfolio of NYSE stocks, including dividends. Table 5 lists the dates and adjustments used to create the combined monthly series.

E. Splicing Daily Data

From February 16, 1885, through January 3, 1928, the Dow Jones returns are the only widely available series. An adjustment for daily dividend yields is made by adding the Cowles yield for the month, divided by the number of trading days, δ_t/N_t, to each daily return in the month from 1885 to 1925. The yield on the CRSP value-weighted portfolio is used in 1926–27.

From January 4, 1928, through July 2, 1962, the S&P composite porfolio is the best available measure of daily stock returns since it is value weighted, and it covers a broader range of stocks than the Dow Jones portfolio. The dividend yield on the CRSP value-weighted portfolio divided by the number of trading days is used to estimate the daily dividend yield. From July 3, 1962, through December 31, 1987, the CRSP value-weighted portfolio of NYSE and AMEX stocks is the best available series since it includes many more stocks than the S&P portfolio, and it includes dividends. Table 5 lists the dates and adjustments used to create the combined daily series. Thus, from February 16,

TABLE 5 Description of Methods Used to Splice Different Stock Indexes into the Combined Monthly and Daily Indexes of Stock Returns

Dates	Price Index	Adjustments
A. Monthly Stock Returns		
2/1802–1/1815	Smith and Cole (1935, table 61) bank stocks	Add estimated monthly dividend yield from (10)
2/1815–12/1820	½ Smith and Cole (1935, table 61) bank stocks plus ½ Smith and Cole (1935, table 62) bank stocks	Add estimated monthly dividend yield from (10)
1/1821–1/1834	Smith and Cole (1935, table 62) bank stocks	Add estimated monthly dividend yield from (10)
2/1834–12/1845	7/27 Smith and Cole (1935, table 62) bank stocks plus 20/27 Smith and Cole (1935, table 69) railroad stocks	Add estimated monthly dividend yield from (10)
1/1846–12/1862	Smith and Cole (1935, table 70) railroad stocks	Add estimated monthly dividend yield from (10)
1/1863–1/1871	Macaulay (1938, table 10) railroad stocks	Adjust for time-averaged price data using (8); add estimated monthly dividend yield from (10)
2/1872–2/1885	Cowles (1939, table C-1) NYSE stocks	Adjust for time-averaged price data using (8)
3/1885–12/1925	Dow Jones (1972) industrial and railroad stocks	Add Cowles (1939, table C-1) dividend yield
1/1926–12/1987	CRSP value-weighted portfolio of NYSE stocks with dividends	None
B. Daily Stock Returns		
2/16/1885–1/3/1928	Dow Jones (1972) industrial and railroad stocks	Add Cowles (1939, table C-1) dividend yield, divided by the number of trading days in the month
1/4/1928 –7/2/1962	Standard & Poor's (1986) composite index of NYSE stocks	Add monthly CRSP value-weighted dividend yield, divided by the number of trading days in the month
7/3/1962 –12/31/1987	CRSP value-weighted portfolio of NYSE and AMEX stocks with dividends	None

NOTE.—Numerals indicate month, day, year.

1885, through December 31, 1987, the combined market return series covers 28,884 days.

V. Statistical Behavior of the Spliced Series

A. Monthly Returns

Table 6 contains the sample moments and 12 autocorrelations for the combined monthly returns from 1802 to 1987, and for 20 year subperiods. It also contains the Box and Pierce (1970) statistic for the joint significance of the 12 autocorrelations ($Q(12)$). For 1802–70, I also show capital gain returns, omitting the estimated dividend yields in (10). For 1857–85, I show the unfiltered versions of the Macaulay and Cowles capital gain returns to judge the effects of the transformation in (7). Because the standard deviations of the dividend yields in table 2 are about 1/20 as large as the standard deviation of capital gain returns, the only noticeable effect of omitting dividends is to lower the mean return. In fact, for the 1802–1987 sample, the dividend yield represents about half the total average return and very little of the variance, so it is important to include dividends when trying to measure the cumulative returns or value from holding stocks.

If one is primarily interested in the response of stock prices to particular types of information (e.g., "event studies"), dividends are unimportant, but the effects of time averaging can be quite important. Consistent with the analysis in Section III, the first-order autocorrelation of the time-averaged returns is .20, and the standard deviation is lower than for the filtered data. Studies of stock volatility should also use the corrected data.

Across the 20-year subperiods, the average total return is between .34% and 1.19% per month, and most of the estimates are more than 2 standard errors above zero. As shown in figure 2 below, the standard deviation of returns differs across sample periods, being almost twice as large from 1921 to 1940 as in the other sample periods. Schwert (1989*a*,*b*, 1990) and others show that heteroscedasticity is an important factor for these stock return series. The skewness coefficients are often large compared with their asymptotic standard errors, but their signs vary across sample periods. The kurtosis and studentized range statistics show the characteristic "fat-tailed" behavior compared with a normal distribution, but this may be partly due to heteroscedasticity (shown later in fig. 2). The autocorrelations are generally small once the effects of time averaging have been eliminated. Nevertheless, most of the index returns are positively autocorrelated at lag 1, which could be due to nonsynchronous trading of the individual stocks in the index (Fisher 1966). This is likely to be more serious in the earlier data, where price quotes are not readily available every day for every stock.

TABLE 6 Sample Mean, Standard Deviation, Skewness, Excess Kurtosis, Studentized Range, and 12 Autocorrelations of Combined Monthly Portfolio Returns, 1802–1987

Sample Period, (N)	Mean	SD	Skewness	Excess Kurtosis	Studentized Range	Autocorrelation at Lag 1	2	3	4	5	6	7	8	9	10	11	12	$Q(12)$
1802–1987 (2,227)	.0071 (7.36)	.0455	.14	8.09	14.61	.09	−.01	−.05	.01	.06	−.02	.01	.03	.04	.03	.00	.00	43.9 (.00)
1802–20 (227)	.0034 (3.37)	.0152	−1.15	4.91	8.48	.03	.11	.10	−.07	−.03	.03	.03	−.03	.01	.05	−.13	.15	17.3 (.14)
1821–40 (240)	.0044 (2.47)	.0276	.96	5.01	8.17	.17	−.12	−.14	−.06	−.04	.01	.04	.06	.08	.08	.13	.00	25.8 (.01)
1841–60 (240)	.0044 (1.41)	.0479	−.46	4.22	8.76	.14	−.10	.14	−.03	−.09	.00	−.09	−.08	.01	.02	−.01	.15	23.5 (.02)
1861–80 (240)	.0102 (3.82)	.0414	−.25	4.01	8.69	.06	.01	.06	.04	.00	−.04	.07	.06	.02	.14	.11	−.02	12.9 (.37)
1881–1900 (240)	.0059 (1.99)	.0458	.10	1.00	6.92	.04	−.05	−.08	−.05	.08	−.13	.06	.07	−.02	.02	−.01	−.04	11.6 (.48)
1901–20 (236)	.0052 (1.94)	.0414	−.46	0.63	5.99	−.03	.15	−.01	.06	.10	−.06	.05	.03	−.06	.02	.02	−.08	13.5 (.33)

1921–40 (240)	.0088 (1.71)	.0797	.43	4.99	8.34	.13	−.01	−.21	.00	.07	.00	.03	.09	.13	.05	−.04	−.02	24.3 (.02)
1941–60 (240)	.0119 (5.05)	.0364	−.37	−.33	5.41	.08	.04	.02	.07	.06	−.03	.07	.03	−.04	−.11	.01	.01	9.7 (.64)
1961–80 (240)	.0079 (2.81)	.0433	−.04	0.99	6.56	.04	−.06	.05	.08	.08	−.11	−.11	−.07	.06	−.05	−.01	.08	15.5 (.22)
1981–87 (84)	.0117 (2.14)	.0500	−.82	4.44	6.89	.08	−.03	−.05	−.08	.20	.01	−.03	−.12	−.14	.05	−.04	−.05	8.9 (.71)
Capital Gain Returns, Omitting Estimated Dividend Yields																		
1802–70 (827)	.0011 (0.88)	.0357	−.26	7.62	11.85	.10	−.07	.10	−.01	−.03	.04	−.01	−.02	.00	.08	.02	.07	32.9 (.00)
Unfiltered Time-averaged Returns																		
1857–85 (338)	.0031 (1.29)	.0438	−.59	6.12	9.66	.20	−.06	.09	.04	−.01	.03	−.02	−.01	.04	.08	.01	−.01	22.9 (.03)

NOTE.—Sample moments are calculated for the combined monthly stock returns, including dividends. The t-statistic for the sample mean is in parentheses below it. Excess kurtosis should be 0 for a normal distribution. The studentized range is the sample range divided by the sample deviation, see David, Hartley, and Pearson (1954). The Box-Pierce (1970) statistic $Q(12)$ measures the joint significance of the 12 lags of the autocorrelations, with the p-value in parentheses below it. The last two rows show the effects of omitting dividend yields and of ignoring the problem of time averaging.

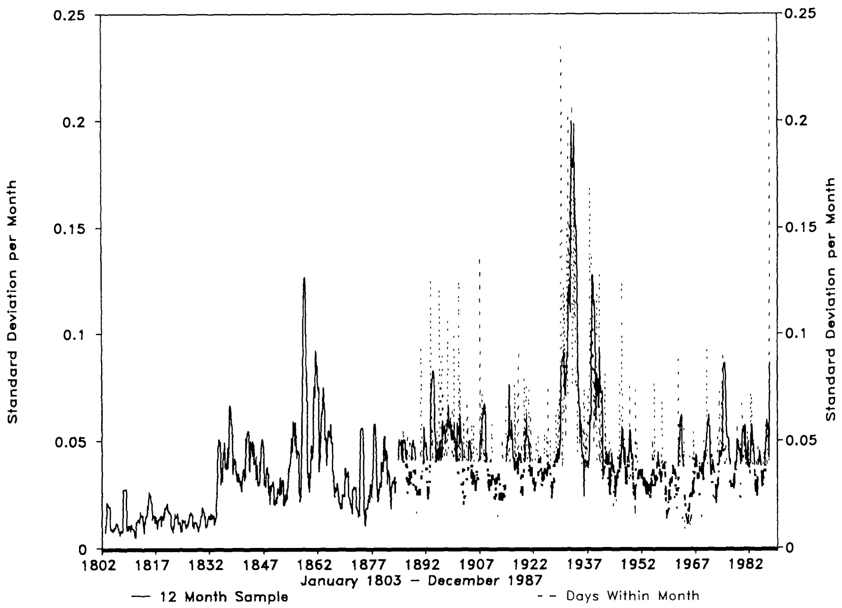

FIG. 2.—Estimates of monthly standard deviation of returns for the spliced monthly portfolios based on the last 12 monthly returns, 1803–1987, and for the spliced daily portfolio based on the daily returns within the month, 1885–1987.

Indeed, the largest first-order autocorrelations are for the 1821–40 and 1841–60 periods (the Smith and Cole [1935] data).

B. Monthly Seasonal Effects

Table 7 shows estimates of means and standard deviations of returns by month of the year for 1802–1987 and the 20-year subperiods. The last column contains asymptotic F-tests of the hypothesis that the means or standard deviations are constant across months, corrected for heteroscedasticity using the techniques of White (1980). Only 2 of the 10 subsample tests for seasonal means and 2 of the 10 tests for seasonal standard deviations are larger than the .05 critical value (shown by an asterisk). Thus, there is very little evidence of seasonality in these market returns.

Previous evidence of seasonality in market portfolios returns (e.g., Rozeff and Kinney 1976) focused on the CRSP equal-weighted portfolio and found higher returns in January. Keim (1983) and others have shown that small firms' stock returns are much higher in January than in other months. These stocks get little weight in value-weighted indexes such as Macaulay, Cowles, and CRSP. Thus, it is not surprising

TABLE 7 Sample Means and Standard Deviations by Month for Monthly Portfolio Returns, 1802–1987

Sample Period	January	February	March	April	May	June	July	August	September	October	November	December	F-Test
Sample Mean Returns by Month													
1802–1987	.0100	.0054	.0078	.0076	.0045	.0075	.0085	.0150	−.0026	.0034	.0069	.0111	1.68
1802–20	−.0047	.0057	.0086	−.0021	−.0015	.0125	−.0041	.0067	.0075	.0027	.0021	.0070	3.03*
1821–40	.0104	.0069	.0028	.0072	.0056	.0076	.0013	.0056	.0018	.0062	−.0065	.0040	.69
1841–60	−.0201	.0213	.0229	−.0010	.0279	.0096	−.0124	.0053	−.0076	−.0085	−.0073	.0222	3.25*
1861–80	.0260	.0115	.0018	.0072	.0028	.0011	.0206	.0093	.0003	.0183	.0162	.0075	.90
1881–1900	.0169	−.0014	.0022	.0133	−.0048	−.0048	.0068	.0332	.0001	.0047	.0084	−.0041	1.29
1901–20	.0031	−.0135	.0236	.0064	.0052	.0063	.0036	.0103	.0068	.0036	−.0018	.0093	1.18
1921–40	.0197	.0116	−.0228	.0156	−.0114	.0223	.0423	.0415	−.0215	−.0115	.0089	.0107	1.54
1941–60	.0100	.0017	.0167	.0088	.0224	.0141	.0172	.0021	−.0035	.0064	.0163	.0302	1.70
1961–80	.0217	.0022	.0091	.0118	−.0065	−.0041	.0074	.0105	.0006	.0076	.0216	.0124	.87
1981–87	.0254	.0131	.0235	.0103	.0069	.0163	−.0111	.0426	−.0229	.0058	.0173	.0132	1.51
Sample Standard Deviations by Month													
1802–1987	.0416	.0333	.0435	.0506	.0518	.0417	.0498	.0467	.0464	.0524	.0445	.0388	2.30*
1802–20	.0215	.0108	.0144	.0124	.0180	.0123	.0134	.0113	.0155	.0125	.0179	.0112	.42
1821–40	.0290	.0277	.0289	.0392	.0310	.0229	.0367	.0233	.0186	.0297	.0215	.0188	.51
1841–60	.0365	.0358	.0488	.0467	.0409	.0377	.0312	.0416	.0408	.0626	.0506	.0686	.95
1861–80	.0447	.0292	.0388	.0297	.0655	.0353	.0308	.0305	.0482	.0532	.0410	.0358	1.04
1881–1900	.0351	.0320	.0383	.0366	.0589	.0379	.0667	.0504	.0431	.0479	.0413	.0460	1.51
1901–20	.0377	.0296	.0458	.0480	.0419	.0304	.0508	.0409	.0413	.0513	.0447	.0295	1.09
1921–40	.0418	.0500	.0723	.1097	.0965	.0880	.0878	.0874	.0907	.0746	.0673	.0461	2.25*
1941–60	.0376	.0321	.0382	.0397	.0314	.0332	.0361	.0334	.0436	.0324	.0425	.0296	.84
1961–80	.0579	.0303	.0364	.0472	.0376	.0394	.0456	.0409	.0384	.0557	.0510	.0315	1.49
1981–87	.0607	.0430	.0229	.0340	.0395	.0239	.0315	.0650	.0365	.1069	.0479	.0365	1.86*

NOTE.—The F-tests in the last column test the hypothesis that the means or standard deviations are equal across all months. The tests use White's (1980) heteroscedasticity-consistent covariance matrix.

* F-statistics greater than the .05 fractile.

that the value-weighted index returns in table 7 show little sign of seasonality.

C. *Daily Returns*

Table 8 contains sample moments and autocorrelations of daily returns to the spliced index for 1885–1987, and for the subperiods 1885–96, 1897–1906, 1907–16, 1917–27, 1928–37, 1938–47, 1948–57, 1958–67, 1968–77, and 1978–87. All daily returns are multiplied by 100 to be expressed as percentages. The mean percent price changes are small and positive in each subperiod, and the *t*-statistics (in parentheses) are generally larger than two. The standard deviation is about .8% per day for each subperiod, except 1928–37, when it is over 1.9% per day. Thus, the *variance* of daily returns more than quadrupled during the 1928–37 period compared with the rest of the sample. The skewness coefficient is reliably negative in most of the subperiods, although it is positive in the 1928–37 and 1968–77 subperiods. The kurtosis and SR statistics are large in all periods, implying fat-tailed distributions, heteroscedasticity, or both. The very large values in the 1978–87 subperiod are due to the October 1987 stock market crash, when volatility was very high for a short period (see Schwert 1990). The autocorrelations of daily portfolio returns are small, except the first-order autocorrelation from 1948 to 1987. The low first-order autocorrelation for the Dow Jones returns in the nineteenth century, when trading volume was much lower, suggests that infrequent trading cannot explain much of this behavior.[5]

D. *Daily Seasonal Effects*

Table 9 shows means and standard deviations of returns by day of the week. Similar to the evidence in French (1980), Gibbons and Hess (1981), and Keim and Stambaugh (1984), the mean return from the close of trading on Saturday to the close on Monday is negative in each of the subperiods, and most of the other average daily returns are positive. This confirms the results of Lakonishok and Smidt (1988) who analyze the daily Dow Jones returns from 1897 to 1986. Also, the standard deviation for Saturday is about 25% lower than for other days, consistent with the shorter trading hours (about half a day). The standard deviation on Monday is slightly higher than for other days in some subperiods, but the extra time from the close on Saturday to the close on Monday does not have much effect on volatility. This is similar to the results in French and Roll (1986). Thus, the seasonal behavior documented in daily stock market returns since 1928 also show up in the 1885–1927 period. While this does not *explain* the cause of this

5. Lo and MacKinlay (1988) argue that nonsynchronous trading cannot explain many of the autocorrelation patterns in CRSP daily returns.

TABLE 8 **Sample Mean, Standard Deviation, Skewness, Excess Kurtosis, Studentized Range, and 6 Autocorrelations of Combined Daily Portfolio Percentage Returns, 1885–1987**

						Autocorrelation at Lag						
Sample Period (*N*)	Mean	SD	Skewness	Excess Kurtosis	Studentized Range	1	2	3	4	5	6	*Q*(6)
1885–1987 (28,884)	.0395 (6.58)	1.019	−.06	21.38	34.04	.05	−.03	.01	.04	.03	−.02	182.6 (.00)
1885–96 (3,593)	.0175 (1.20)	.8738	−.21	11.02	17.33	−.01	−.02	.03	.02	.03	−.01	11.0 (.09)
1897–1906 (2,990)	.0474 (3.02)	.8578	−.36	8.69	15.70	−.03	−.04	.04	.08	.05	−.05	43.5 (.00)
1907–16 (2,885)	.0202 (1.41)	.7688	−.47	10.85	18.19	−.01	−.01	.00	.05	.08	−.01	27.5 (.00)
1917–27 (3,288)	.0403 (2.88)	.8034	−.31	6.53	14.11	.03	−.03	.02	.00	.03	.00	9.8 (.14)
1928–37 (2,973)	.0170 (.48)	1.933	.38	10.09	14.99	.01	−.04	−.02	.05	.02	−.05	25.0 (.00)
1938–47 (2,954)	.0365 (1.79)	1.107	−.10	10.47	15.44	.06	−.03	.05	.03	.01	.01	23.8 (.00)
1948–57 (2,658)	.0593 (4.19)	.7296	−.85	9.79	15.22	.11	−.07	−.01	.02	.05	−.01	51.1 (.00)
1958–67 (2,518)	.0586 (4.83)	.6098	−.55	13.02	18.57	.17	−.03	.03	.05	.01	−.01	81.3 (.00)
1968–77 (2,497)	.0313 (1.88)	.8295	.29	5.56	10.59	.30	.00	.03	.02	−.02	−.06	243.8 (.00)
1978–87 (2,528)	.0800 (4.12)	.9763	−2.51	54.97	27.55	.13	−.02	−.02	−.03	.07	.04	65.6 (.00)

NOTE.—Sample moments are calculated for the combined daily stock returns, including dividends. All daily returns are expressed as percentage returns (multiplied by 100), with the *t*-statistic for the sample mean in parentheses below it. Excess kurtosis should be zero for a normal distribution. The studentized range is the sample range divided by the sample standard deviation. See David, Hartley, and Pearson (1954). The Box-Pierce (1970) statistic *Q*(6) measures the joint significance of the 6 lags of the autocorrelations, with the *p*-value in parentheses below it.

TABLE 9 Sample Means and Standard Deviations by Day of the Week for Combined Daily Portfolio Percentage Returns, 1885–1987

Sample Period	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	*F*-Tests
A. Means of Percentage Returns by Day of the Week							
1802–1987	−.1250	.0494	.0889	.0512	.1007	.0840	29.69*
1802–20	−.1016	.0341	.0766	−.0061	.0743	.0259	2.95
1821–40	−.0165	.0911	.0729	−.0034	.1658	−.0309	4.25*
1841–60	−.0122	.0380	−.0241	.0127	.0502	.0586	1.09
1861–80	−.1340	.0197	.0543	.0574	.1284	.1122	7.31*
1881–1900	−.3601	.0503	.1322	.0953	.0794	.1002	4.23*
1901–20	−.1237	.0905	.0389	.0288	−.0326	.2313	7.64*
1921–40	−.1670	.0153	.1512	.0997	.1580	.1629	12.63*
1941–60	−.1159	.0628	.1143	.0843	.1434	N.A.	11.87*
1961–80	−.1187	.0088	.1003	.0606	.1020	N.A.	5.38*
1981–87	−.1007	.0891	.1736	.0906	.1381	N.A.	4.01*
B. Sample Standard Deviations of Percentage Returns by Day of the Week							
1802–1987	1.1176	1.0068	1.0806	.9830	.9998	.8092	45.48*
1802–20	.9515	.8688	.9320	.8346	.9343	.6847	11.82*
1821–40	.9941	.8523	.8500	.8537	.8540	.7047	7.44*
1841–60	.8267	.7950	.7224	.8280	.8188	.5884	11.29*
1861–80	.8806	.8182	.8587	.8658	.7728	.5496	27.94*
1881–1900	2.0428	1.7870	2.2822	1.9204	2.0203	1.3617	16.57*
1901–20	1.1174	1.3585	1.1046	1.0454	1.0888	.8099	13.33*
1921–40	.8411	.7678	.7423	.6509	.6488	.4601	14.51*
1941–60	.7092	.6360	.5951	.5535	.5058	N.A.	6.76*
1961–80	.9108	.7784	.8853	.7879	.7626	N.A.	2.96
1981–87	1.3111	.9014	.9042	.8682	.8141	N.A.	3.67*

NOTE.—The New York Stock Exchange traded for ½ day on Saturdays from 1928 through May 1952. N.A. indicates Saturday returns are not available. The *F*-tests in the last column test the hypothesis that the means or standard deviations are equal across all days of the week. The tests use White's (1980) heteroscedasticity-consistent covariance matrix.

* *F*-statistics greater than the .01 fractile.

behavior, it does lend credence to the contention that these facts are not simply reproducing the evidence already discovered by previous researchers on the same data set (the problem discussed by Merton [1987]).

E. Stock Volatility Estimated from Monthly and Daily Returns

Following French, Schwert, and Stambaugh (1987), I use all the daily returns R_{it} in the month to calculate a standard deviation for month i,

$$\sigma(R_t) = \left[\sum_{i=1}^{N_t} (R_{it} - \bar{R}_i)^2 + 2 \sum_{i=1}^{N_t - 1} (R_{it} - \bar{R}_i)(R_{i+1t} - \bar{R}_i) \right]^{1/2}, \quad (11)$$

where there are N_t trading days in month t and $\bar{R}_i$ is the average return in the month. The second term in (11) reflects the large first-order autocorrelation in daily portfolio returns. This estimator has the dimension of a monthly instead of a daily standard deviation because it is not divided by the sample size N_t.

Figure 2 plots the estimates of the monthly standard deviation of returns based on daily returns in the month. It also plots the rolling 12-month standard deviation for the monthly returns.[6] The rolling 12-month sample induces artificial smoothness, but the series based on nonoverlapping samples of daily returns is less smooth. These two series of estimates have a correlation coefficient of .98. The volatility of the early bank stock returns is noticeably lower than for the rest of the data. When railroad stocks enter the portfolio in 1834, there is a large jump in the estimated standard deviation. As discussed by Schwert (1989*b*), there are many financial crises in the nineteenth century when stock volatility increased. Of course, the Great Depression stands out as the episode when stock returns were exceptionally volatile. In recent years, the 1973–74 period and the October 1987 crash show up as periods of high volatility.

VI. Conclusions

The combined series of monthly returns from 1802 to 1987 and daily-returns from 1885 to 1987 provide a long historical record of stock price behavior. The estimates in tables 6 and 8 and the plots of volatility in figure 2 show remarkable homogeneity for these series through time. Moreover, the seasonal patterns of monthly and daily stock returns are similar in the nineteenth and twentieth centuries. This is surprising because of the large changes in the U.S. economy over this period, the

6. Schwert (1989*a*, 1989*b*, 1990) and Pagan and Schwert (1990), among others, argue for more elaborate measures of volatility. Nevertheless, the rolling standard deviation is a reasonable approximation to these better, but more complex, measures. The standard deviation for month t is based on the last 12 monthly returns.

growth in the proportion of wealth represented by traded common stocks, and the changes in the market microstructure for stock trading. The monthly portfolio grows from seven bank stocks in 1802–14 to over 1,500 stocks representing a broad spectrum of industries in 1987. As stressed by Schwert (1989*a*), the most unusual period of stock returns is the Great Depression from 1929 to 1939. This is most obvious because of the high volatility of returns in figure 2.

One of the main contributions of this article is to identify and correct the deficiencies of some of the early indexes of stock prices. In particular, the use of time-averaged data by Cowles (1939) (and apparently Macaulay 1938) induces positive autocorrelation of returns and reduces the variability of returns. Also, most of the pre-CRSP indexes do not include dividends in measuring returns. I show that this mainly affects estimates of mean returns. I estimate the dividend yields for 1802–70.

Because of the recent interest in long-run behavior of stock prices (Fama and French 1988*a*, 1988*b*), and concerns that the CRSP data set has been analyzed too frequently (Merton 1987), these new estimates of pre-1926 stock returns are important for both economic historians and financial economists. For example, Romer (1986*a*, 1986*b*, 1989) and Shapiro (1988) have studied macroeconomic volatility in the nineteenth century to see whether stabilization policies adopted after World War II have had an important effect in reducing fluctuations.

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CORRECTED
TABLE 9 **Sample Means and Standard Deviations by Day of the Week for Copmbined Daily Portfolio Percentage Returns, 1885–1987 (for G. William Schwert, "Indexes of U.S. Stock Prices from 1802 to 1987," *Journal of Business* 63, no. 3 [1990]: 422)**

Sample Period	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	*F*-Tests
	A. Means of Percentage Returns by Day of the Week						
1885–1987	−.1250	.0494	.0889	.0512	.1007	.0840	29.69*
1885–96	−.1016	.0341	.0766	−.0061	.0743	.0259	2.95
1897–1906	−.0165	.0911	.0729	−.0034	.1658	−.0309	4.25*
1907–16	−.0122	.0380	−.0241	.0127	.0502	.0586	1.09
1917–27	−.1340	.0197	.0543	.0574	.1284	.1122	7.31*
1928–37	−.3601	.0503	.1322	.0953	.0794	.1002	4.23*
1938–47	−.1237	.0905	.0389	.0288	−.0326	.2313	7.64*
1948–57	−.1670	.0153	.1512	.0997	.1580	.1629	12.63*
1958–67	−.1159	.0628	.1143	.0843	.1434	N.A.	11.87*
1968–77	−.1187	.0088	.1003	.0606	.1020	N.A.	5.38*
1978–87	−.1007	.0891	.1736	.0906	.1381	N.A.	4.01*
	B. Sample Standard Deviations of Percentage Returns by Day of the Week						
1885–1987	1.1176	1.0068	1.0806	.9830	.9998	.8092	45.48*
1885–96	.9515	.8688	.9320	.8346	.9343	.6847	11.82*
1897–1906	.9941	.8523	.8500	.8537	.8540	.7047	7.44*
1907–16	.8267	.7950	.7224	.8280	.8188	.5884	11.29*
1917–27	.8806	.8182	.8587	.8658	.7728	.5496	27.94*
1928–37	2.0428	1.7870	2.2822	1.9204	2.0203	1.3617	16.57*
1938–47	1.1174	1.3585	1.1046	1.0454	1.0888	.8099	13.33*
1948–57	.8411	.7678	.7423	.6509	.6488	.4601	14.51*
1958–67	.7092	.6360	.5951	.5535	.5058	N.A.	6.76*
1968–77	.9108	.7784	.8853	.7879	.7626	N.A.	2.96
1978–87	1.3111	.9014	.9042	.8682	.8141	N.A.	3.67*

NOTE.—The New York Stock Exchange traded for ½ day on Saturdays from 1928 through May 1952. N.A. indicates Saturday returns are not available. The *F*-tests in the last column test the hypothesis that the means or standard deviations are equal across all days of the week. The tests use White's (1980) heteroscedasticity-consistent covariance matrix.

* *F*-statistics greater than the .01 fractile.