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Are National Stock Markets Linked?

ANALYSTS generally agree that national asset markets have become more integrated in recent years. This process began with the relaxation of controls on capital movements in the 1950s and was followed, during the last decade or so, by the gradual relaxation of exchange controls. Recently, substantial improvements also have been made in computer and communication technology that have lowered the cost of international information flows and cross-border financial transactions.[1]

This globalization of financial activities has led some to argue that the behavior of stock prices in 1987 was influenced by international events to a greater extent than anyone had thought previously. For example, in its discussion of 1987, the report by the Presidential Task Force on Market Mechanisms (commonly known as the Brady Commission) suggests that "[i]nvestors made comparisons of valuations in different countries, often using higher valuations in other countries as justification for investing in lower valued markets. Consequently, a process of ratcheting up among worldwide stock markets began to develop."[2] In other words, a higher level of prices in one market increased the level in other markets. As for the fall in prices, the Brady Commission report notes that "[w]hat may have appeared strictly a 'Wall Street' collapse was the result of the cumulative impact of several developments occurring simultaneously in several other financial centers."[3]

There appears to be no one reason that explains the worldwide decline in equity values during October 1987. The timing and magnitude of the declines differed across markets around the world. Even so, all of the organized markets fell.[4] This coincident fall suggests that changes in the markets are indeed related to one another.

The behavior of stock prices since the October crash suggests that markets around the world do not move in tandem. As interpreted by Cowan (1988), "the first quarter of 1988, if nothing else, dispelled the popular notion that there is one synchronized, global market." While stock prices in the United States were 9.8 percent below their value on October 16, stock prices in Japan were

[1]Cooper (1986) and Bryant (1987) discuss these and related issues.

[2]Presidential Task Force on Market Mechanisms (1988), p. 10.

[3]Ibid., Study I, p. 2. Most of the reasons offered in the report to explain the decline, however, are related to economic developments in the United States or changes in the dollar's value in foreign exchange markets. The primary reasons for the break in equity prices given are: the persistent and large budget and trade deficits in the United States; instability in foreign exchange markets, stemming primarily from the continued fall in the dollar after the Louvre accord; the international rise in interest rates; and the threatened end to takeovers in the United States. For more, see ibid., Study I, pp. 11–13.

[4]Roll (1988) provides an analysis of the different markets' behavior.

only 0.4 percent below their pre-crash level by the end of the first quarter. The German stock price index at the end of March 1988, in contrast, was 28.3 percent below its pre-crash level. While some markets had recovered some or all of their October 1987 loss, others clearly had not.

These disparate movements raise questions about just how the different stock markets around the world are related. Given the increase in Japanese stock prices since the crash, should we be surprised not to have had a similar rise in the United States? Or is it really unusual for all markets to move together as they did during the week of October 19, 1987?

In this article, we examine the statistical relationship between the levels and movements of stock price indexes for Germany, Japan, the United Kingdom and the United States, using daily data for July 1987 through January 1988 and monthly data for the past 31 years. Thus, we can examine the relationships both over a short period encompassing the October crash and across a longer horizon, in order to put the events of last year into some long-run perspective.

HOW SHOULD STOCK PRICES BE LINKED?

In standard models of stock price determination, the level of a stock's price equals the present value of expected future dividends. Anything that changes the fundamentals — that is, the expected future dividends or the interest rate at which those dividends are discounted — affects the price of the stock.[5]

One way of thinking about linkages across national stock markets is to start with an extreme form of linkage and to examine what loosens these links. Suppose that the transaction costs of buying and selling stocks and foreign exchange anywhere in the world are zero. Suppose also that investors are risk-neutral; that is, stockholders are indifferent to holding different stocks only if they yield the same expected return. For all stocks in the world to be held, the expected return in terms of any common currency must be the same for holding any stock anywhere in the world. This idea can be written as

$$(1)\quad Eh_{i,t} = Eh_{j,t} + E\Delta e_t,$$

where $Eh_{i,t}$ is the expected rate of return from holding a stock in country i in terms of i's currency in period t, $Eh_{j,t}$ is the expected rate of return from holding a stock in country j in terms of j's currency and $E\Delta e_t$ is the expected rate of change in the price of country j's currency in terms of country i's currency. For convenience, we can call this relationship "stock return parity."[6] If it existed, stock return parity would imply that the expected return from holding stock of a domestic firm is the same as the expected return from holding the stock of a foreign firm.

Linkages of Price Levels

Even if stock return parity holds, unexpected events will guarantee that there will be no reliable relationship between the levels of various stocks' prices, even in the same currency. For example, suppose there is an unexpected permanent increase in the demand for Hondas relative to Fords which increases the expected earnings and dividends of Honda relative to Ford. Because of the change in expected dividends, the price of Honda stock will increase relative to the price of Ford stock. This will occur even with stock return parity. An unexpected increase in the price of Honda stock produces a capital gain, which means that the *ex post* rate of return from holding Honda stock will be higher than from holding Ford stock. This is perfectly consistent with stock return parity, which holds that the *expected* rates of return are the same both now and in the future. Moreover, once the price of Honda stock increases, we should hardly expect that the price of Ford stock will rise just because the price of stock in Honda is higher.[7] This analysis holds both for companies in the same national market and for companies in different national markets. Internationally, even though financial markets may be increasingly integrated, the relative levels of stock prices (or indexes of stock prices) around the world will diverge, because they represent the valuation of different firms.

The preceding argument can be demonstrated more formally. In terms of *ex post* rates of return, equation 1 can be written as

$$(2)\quad h_{i,t} = h_{j,t} + \Delta e_t + \epsilon_{i,t} - \epsilon_{j,t} - \epsilon_{e,t},$$

[5]The major alternative to models based on the fundamentals is known as a rational bubble model. Essentially, this model allows prices to deviate from that predicated on the fundamentals. For a discussion of the differences between these models, see Santoni (1987) and Santoni and Dwyer (1988).

[6]In effect, this is uncovered interest parity applied to stocks. We ignore the second-order term $Eh_{j,t}\Delta e_t$.

[7]If firms have firm-specific capital, the relative change in price levels can be permanent.

where $\epsilon_{i,t}$ is the unexpected part of the holding period return for stock i in period t, $\epsilon_{j,t}$ is the unexpected part of the holding period return for stock j and $\epsilon_{e,t}$ is the unexpected part of the rate of change of the exchange rate. If expectations are rational in the sense of Muth (1961), then the ϵ's are independent of the expected part of the holding period returns.[8] Assume that the variances and covariances of the ϵ's are constant. If we assume that dividends are zero, then equation 2 can be written as

$$(3)\quad p_{i,t+1} - p_{i,t} = p_{j,t+1} - p_{j,t} + e_{t+1} - e_t + \epsilon_{i,t} - \epsilon_{j,t} - \epsilon_{e,t},$$

where p is the logarithm of the price of the stock, e is the logarithm of the exchange rate and the subscript $t+1$ denotes the price one period in the future. Rearranging terms, equation 3 can be written as

$$(4)\quad p_{i,t+1} - p_{j,t+1} - e_{t+1} = p_{i,t} - p_{j,t} - e_t + \epsilon_{i,t} - \epsilon_{j,t} - \epsilon_{e,t}.$$

Define $x = p_i - p_j - e$. Then equation 4 can be rewritten as

$$(5)\quad x_{t+1} = x_t + \epsilon_{i,t} - \epsilon_{j,t} - \epsilon_{e,t}.$$

Equation 5 shows that relative stock prices next period simply are equal to relative stock prices this period plus the difference between the unexpected parts of the holding period returns ($\epsilon_{i,t} - \epsilon_{j,t}$) and the unexpected change in the exchange rate ($\epsilon_{e,t}$). In other words, even if expected rates of return are identical, relative stock prices in terms of a common currency are a random walk. When the relative stock price indexes take a random step up or down, the relative stock prices show no tendency to return to any particular value.

This is important because it means that, even if the expected holding period returns of two stocks were perfectly correlated, the levels of the prices will show no stable relationship. Because relative stock prices are characterized as random walks, correlations between the levels of national stock price indexes are unstable. The levels of stock prices in different markets may rise or fall together, or move in opposite directions. Moreover, the size of correlations of the stock price levels will depend on the sample period used and the unexpected changes in the two countries' stock prices and exchange rates in that period.

Another way of thinking about a time-series process that is a random walk is in terms of a "unit root."[9] Although a random walk is a particular kind of unit-root process, the two are not synonymous. While its evolution may have additional components, a unit-root series wanders around in the same way that a random walk does. For example, neither a random walk nor a unit-root process has a tendency to return to any particular value over time. The algebra above has been simplified considerably by assumptions that make the relative stock price indexes a random walk. Rather than maintain these assumptions (for example, constant variances of the unexpected parts of the returns from holding stocks and the changes in the logarithm of the exchange rate), we directly test for unit roots in the empirical analysis.

Rates of Return

Stock return parity, while useful for making the point above, is illustrative rather than descriptive. Stock return parity implies that, since the expected rates of return from holding different stocks are the same, the correlation of expected returns is one. It is unlikely that stock return parity holds. If stock return parity holds across national borders, it should hold within a country as well; this means that differences between the expected returns on domestic stock should be unpredictable. This prediction, however, is inconsistent with the data.[10]

Factors Decreasing the Correlations — Evidence indicates that expected returns from holding stock in both the United States and other

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[8]Actually, the only implication that we need is that the expected part of the holding period return and the unexpected part are uncorrelated.

[9]The precise definition of a unit root is based on the autoregressive representation of a series. If the fundamental moving-average representation of a series, say x, has an autoregressive representation, then it can be written as

$$[1 - \alpha(L)]x_t = \epsilon_t,$$

where L is the lag operator such that $Lx_t = x_{t-1}$ and $\alpha(L) = \Sigma\alpha_i L^i$. The polynomial in the lag operator $\alpha(L)$ always can be written as $\alpha(L) = (1 - \beta_1 L)\beta(L)$. If there exists a root β_1 that is equal to one, then the series x is said to have a unit root.

[10]See Malkiel (1985).

countries are related to the riskiness of holding stock relative to other financial assets. To the extent that the variability of the return from holding a stock cannot be diversified away, expected rates of return are higher for riskier stocks.[11] This finding suggests that stock return parity is unlikely to hold. Expected rates of return differ across firms and industries; available evidence suggests that country risk also is important.[12]

There also are transaction costs associated with buying and selling stocks. Today, explicit transaction costs are relatively unimportant in buying and selling large blocks of stock around the world. With improvements in communication and the ability to order trades over phone lines, the explicit cost to someone in London of buying AT&T stock in New York is little more than the cost to someone in New York.

Nonetheless, government restrictions are part of the costs of executing a transaction, and these restrictions have been important at times in executing international transactions. Exchange controls were one of the ways that countries maintained the fixed-exchange-rate regime in place until 1973. By limiting access to foreign exchange, governments sought to manipulate the demand for their currency relative to foreign currency, thereby assisting their attempts to maintain a fixed exchange rate. In some cases, governments also restricted foreigners' ability to purchase domestic financial assets. Both types of controls have been declining gradually since the demise of fixed exchange rates.[13]

Factors Increasing the Correlations — Some forces make expected returns in different countries positively related even if there were no international financial transactions. If the demand for automobiles increases in the United States, which increases the expected earnings and dividends of domestic automobile companies, it also can increase the expected earnings of automobile companies like Honda, which are headquartered in Japan and sell automobiles in the United States. Consequently, changes in stock prices in the United States and Japan can be positively correlated even if no foreigner can buy stock in either country. This example, while trivial in some respects, points out that international trade creates a link between at least some stocks in different markets.

In addition to trade, multinational operations by firms create links through ownership of real assets that can affect firms headquartered in different countries. For example, Ford manufactures automobiles in Europe. A recession in Europe would likely decrease the demand for Ford automobiles and lower Ford's earnings, dividends and stock price on the New York Stock Exchange.

Finally, relative to data on individual firms' shares, stock index data will have a higher correlation than the correlation of returns from randomly selected stocks on different markets. All of the actual data that we use below are indexes of stock prices. Consequently, the indexes average out much of the variation attributable to individual firms or industries. Thus, if there were no factors that differentially affect firms in different countries, the expected returns in any common currency measured by these indexes would be virtually the same.

DAILY DATA SURROUNDING THE CRASH

In this section, we examine daily values of stock price indexes for seven months surrounding the crash for evidence of the "ratcheting up" in stock markets suggested by the Brady Report. Daily values of stock price indexes from Germany, Japan, the United Kingdom and the United States for July 1, 1987, through January 29, 1988, are used.[14] This period includes three months before the October 1987 crash and three months after it. To make the relative values of the indexes comparable, all of the measures are set to a base value of 100.0 on July 1, 1987. Because the markets are open in daylight hours in different time zones, the markets in our sample are not all open at the same time. We

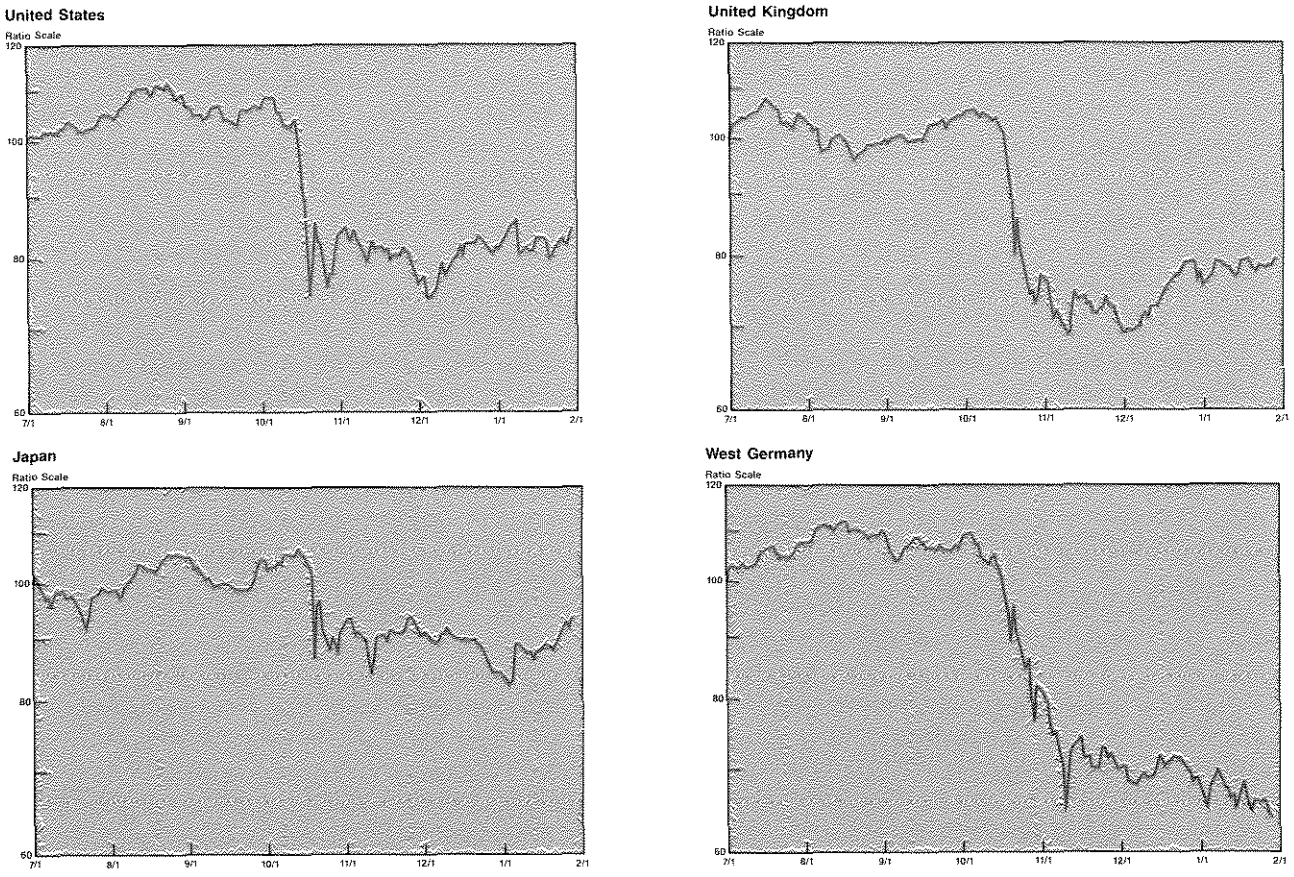
[11]Malkiel (1985) summarizes the evidence. The riskiness of a firm's stock can be divided into its relationship with general movements in the market (market risk) and the factors that cause it to deviate from the market (non-market risk). Non-market risk includes those factors that influence a specific firm or industry. The idea that there are factors that cause firms or industry groupings of firms to deviate from the market portfolio applies also to the divergent movements of national stock price indexes.

[12]See Solnik (1974); Cho, Eun and Senbet (1986).

[13]For an annual discussion of changes in these controls on a country-by-country basis, see any issue of the International Monetary Fund's *Exchange Arrangements and Exchange Restrictions.*

[14]The daily stock market indexes, both in terms of local currency and U.S. dollars, are from Morgan Stanley's *Capital International Perspective.* The indexes are market-weighted price averages without dividends reinvested.

Chart 1
Levels of Stock Price Indexes (7/1/87 = 100) in local currency



define a trading day as starting with the opening of the European markets.

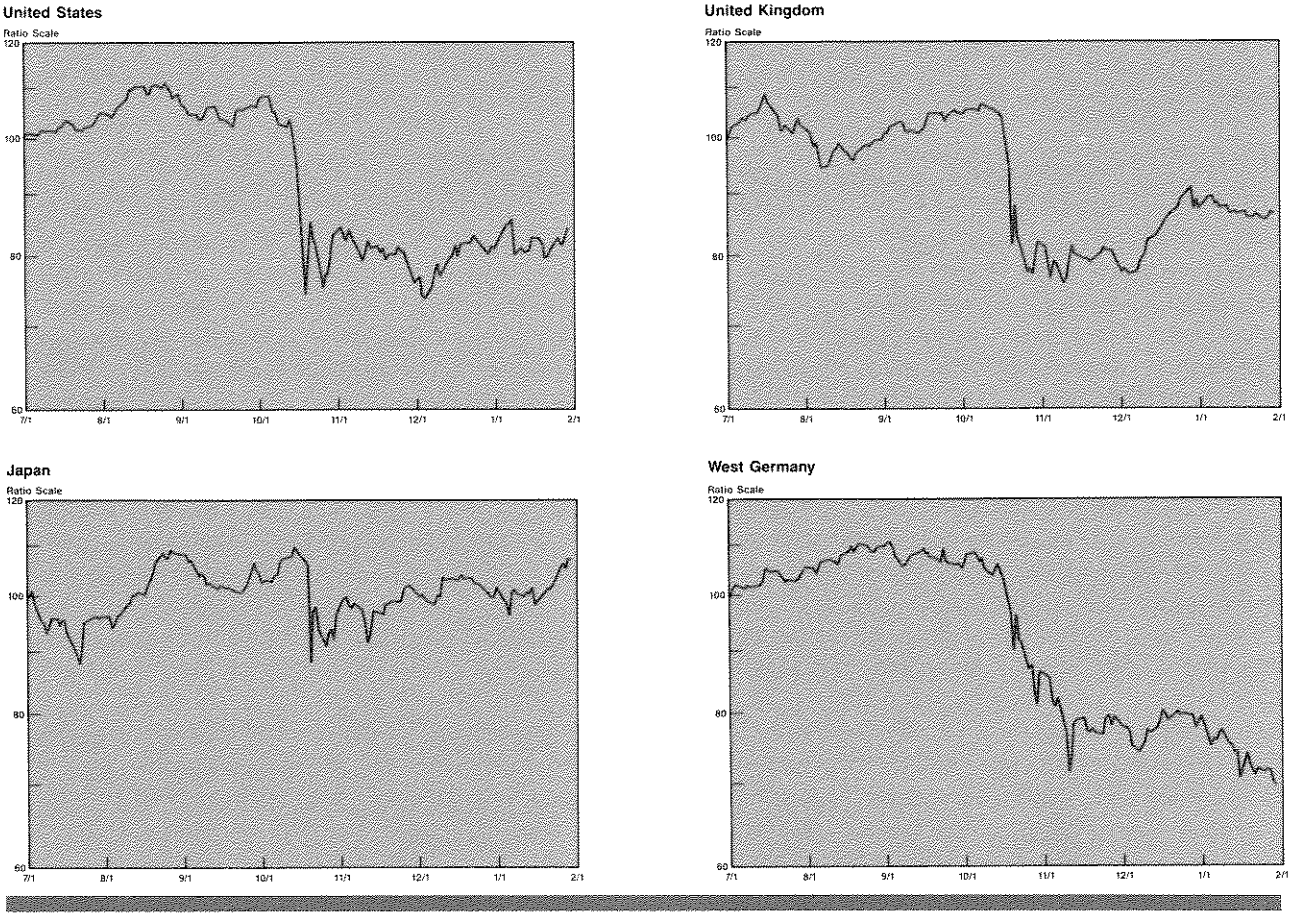
The levels of the different indexes, measured in terms of local currency, are shown in chart 1. The behavior of the indexes reveals some common movement during this period, especially around October 19. All of the indexes decline sharply from the middle of October to the end of the month.[15] Before and after the crash, however, there appears to be little common movement in the levels of the indexes.

While the behavior of the indexes in terms of local currency is interesting, the indexes should be measured in terms of some common currency to be directly comparable. Comparing stock prices in the United States in dollars and stock prices in the United Kingdom in pounds is much like measuring the price of apples in dollars and pounds and comparing the movements of the two. We measure the different indexes in terms of U.S. dollars.

The dollar-denominated indexes in chart 2 show similar patterns to those in chart 1. The differences in behavior of the different indexes since the crash, however, are striking. Based on the data in chart 2, the U.S. and U.K. indexes increase only slightly after the crash, while those in Germany continue to fall. The index for Japan, however, returns roughly to its value immediately following the crash. By January 29, 1988, stock prices in Germany, the United Kingdom and the United States are still below their October 19 levels. For example, stock prices in the United States at the end of January are about 17 percent lower than on

[15]The sizes of the decreases in stock prices in October 1987 differ substantially. The decline in the United States was 21.6 percent, slightly below the average decrease of 24.6 percent for a sample of 23 countries. For example, stock prices fell as little as 5.8 percent in Austria and as much as 45.8 percent in Hong Kong (measured in U.S. dollars). For further discussion, see Roll (1988).

Chart 2
Levels of Stock Market Indexes (7/1/87 = 100) in U.S. dollars



October 12, 1987 — one week before the crash. Similarly, prices in the United Kingdom and in Germany at the end of January are about 18 percent and 33 percent below their October 12 levels. In sharp contrast, the Japanese stock market index on January 29 is less than 1 percent lower than on October 12.

Despite these different movements of the levels of stock prices, there is some common behavior in the changes in the different country indexes. A simple way to see this is to calculate the number of days every index increased or decreased. During the seven months covered in chart 2, there are 20 days when all the indexes increased and 16 days when all decreased. Little significance should be attached to the greater number of coincident increases than decreases: with the exception of Germany, increases predominate in each country during the period. Coincident increases are more likely than decreases even if the changes are unrelated. Some coincident increases and decreases in all of the indexes are expected by chance alone. If the probability of an increase in one country is unrelated to events in other countries, the probability of a coincident increase in all of the indexes is about 7.7 percent, and the probability of a coincident decrease in all of the indexes is about 4.85 percent.[16] This implies that these data would have about 19 days of coincident movements due to chance alone, substantially less than the actual 36 days with increases or decreases in all four in-

[16]For the data in chart 2, the indexes decrease in 52.7 percent of the days in Germany, 49.0 percent of the days in Japan, 42.0 percent of the days in the United Kingdom and 44.7 percent of the days in the United States. If the changes are unrelated, the joint probability of coincident decreases is simply the product of the proportions of days with decreases to the total, which is 4.85 percent or about 7.2 days. The joint probability of the four indexes increasing or staying the same is about 7.7 percent or about 11.5 days. If the changes in the indexes are unrelated, the total number of days expected to have coincident movements is about 18.7 days, with a standard deviation of this expected value of about 4.1 days.

Table 1

Correlations of Stock Price Indexes: July 1, 1987–January 29, 1988 (logarithms in terms of dollars)

Full period				
Country	**United States**	**Germany**	**Japan**	**United Kingdom**
United States	1.00			
Germany	0.93*	1.00		
Japan	0.22*	0.10	1.00	
United Kingdom	0.90*	0.86*	0.16	1.00

Before October 19				
Country	**United States**	**Germany**	**Japan**	**United Kingdom**
United States	1.00			
Germany	0.75*	1.00		
Japan	0.40*	0.61*	1.00	
United Kingdom	−0.56*	−0.38*	−0.14	1.00

After week of October 19				
Country	**United States**	**Germany**	**Japan**	**United Kingdom**
United States	1.00			
Germany	−0.01	1.00		
Japan	0.22	−0.38*	1.00	
United Kingdom	0.56*	−0.32*	0.52*	1.00

*Significantly different from zero at 5 percent level.

dexes. If the changes across stock markets were unrelated, the probability of observing 36 coincident changes or more would be much less than 1 percent. This suggests that it is likely that changes in the indexes are related.

Correlations Among the Levels of Stock Prices

There does not appear to be a stable relationship among the levels of stock prices (table 1). Except for Japan, the evidence for the whole period suggests that the indexes are highly correlated. If one examines the correlations of the levels of stock prices before and after the crash, however, the correlations change dramatically. For example, the correlation of the U.K. index with the U.S. index is about 0.90 for the whole period. Before the crash, however, the correlation is −0.56, while, after the crash, it is 0.56. Conversely, the correlations for the U.S. and German stock indexes are 0.93 for the whole period, 0.75 before the crash and −0.01 afterwards.

This instability is precisely what one would expect if the relative stock price indexes are random walks with no long-run relationships between their levels. The negative correlation between the index for the United States and the United Kingdom before October 19, though, is not what would be expected if stock prices around the world were "ratcheting upward" before the crash.

Tests for Unit Roots

We can test whether, as equation 5 implies, the relative stock price indexes have unit roots.[17] Test statistics to determine whether the levels of the relative stock indexes have unit roots are presented in table 2. Two periods are analyzed: one uses data from the full period; the other examines

[17]The test essentially consists of implementing the Dickey-Fuller test (1979) on the ratio of stock price indexes. The reported t-ratios are those on the lagged level of the ratio in the relevant equation. All equations include a constant term and one lagged value of the dependent variable. The critical values for the test are from Fuller (1976), p. 373.

An alternative interpretation of this test in terms of cointegration as defined by Granger (1986) and discussed by Engle and Granger (1987). Under this interpretation, we are testing whether two stock price indexes are cointegrated with a coefficient of unity in the equation relating the two indexes.

Table 2

Test Statistics for Unit Roots in Relative Stock Price Indexes: July 1, 1987–January 29, 1988 (logarithms denominated in dollars)

Full period			
Country	**Germany**	**Japan**	**United Kingdom**
United States	−1.67	−0.65	−2.16
Germany		−0.53	−0.43
Japan			−1.06

Before October 19			
Country	**Germany**	**Japan**	**United Kingdom**
United States	−1.03	−0.32	−0.40
Germany		−1.86	−1.57
Japan			−1.61

*Significantly different from zero at 5 percent level.

the relationship before the crash. A t-ratio less than about −2.89 is inconsistent with the hypothesis that the levels of two series have a unit root. The test statistics in table 2 are well above the 5 percent critical value, consistent with the hypothesis that all of the different relative stock indexes have unit roots. These results provide no reason to expect that, given an increase in the U.S. index, for example, the Japanese index also will rise, or fall. That is, there is no "normal" level of these indexes relative to each other. This is especially important because, in contrast to the conclusion of the Brady Commission, it is inconsistent with the notion that the markets rose as one during 1987 before the crash. Furthermore, it indicates that using the levels of the stock market indexes to judge whether there is any relationship between the markets is fallacious.

Correlations of Changes of the Indexes

The evidence indicates that there is no reliable relationship among the levels of the indexes. Simple correlations of changes in daily stock prices can be used to measure the extent of the association between the rate of increases in the indexes (table 3). For the whole period, the correlations among the changes in the U.S. index and those of the other countries range from 0.64 for Japan to 0.32 for Germany. The correlations among the indexes for Germany, Japan and the United Kingdom range from 0.56 to 0.15. At the 5 percent marginal significance level, all but the Japan/United Kingdom correlation are different from zero.

These correlations are, on average, noticeably lower when the week of the crash in prices is excluded from the correlations. Correlations without the data for the week of October 19 are presented in the lower part of table 3. All but two are lower than those for the whole period. The only higher correlation for a subperiod is the correlation between changes in the Japanese and German stock indexes, a correlation of 0.22 excluding the week of the crash and 0.21 for the whole period. These results are consistent with the notion that movements in the indexes, unlike levels of the indexes, are indeed related.

Summary of the Short-Term Results

The daily data for the period around the October 1987 crash provide little support for the notion of prices ratcheting up or down together. Rather, they indicate that there is no constant relationship between the levels of the indexes. There is, however, a positive relationship among changes in the indexes, a finding consistent with the view that either financial transactions or international trade of goods and services affect the different indexes in the same direction.

STOCK PRICE INDEXES SINCE 1957: A LONGER-RUN VIEW

Investigating the link between stock markets using monthly data spanning the past 31 years provides a useful perspective on the preceding results. Chart 3 shows monthly average indexes of industrial share prices for each of the four countries for 1957 through 1987. All stock price indexes are denominated in terms of U.S. dollars.[18] Although changes in stock prices like those in October have been quite rare during the past few de-

[18]The monthly data are from the International Financial Statistics (IFS) data tape of the International Monetary Fund. The U.S. data are the monthly averages of the daily close of 400 Standard and Poor's industrials on the NYSE, the figures for Germany are the averages of daily quotations covering 95 percent of common shares of industrial companies headquartered in Germany, the Japanese data are the averages of daily closing prices for all shares traded on the first section of the Tokyo exchange and the U.K. data are the average of daily quotations of 500 industrial ordinary shares on the International Stock Exchange in London. The exchange rates used to convert the stock indexes into dollars are the monthly average rates from the IFS data tape.

Table 3

Correlations of Changes of Stock Price Indexes: July 1, 1987–January 29, 1988 (changes of logarithms in terms of dollars)

Full period

Country	United States	Germany	Japan	United Kingdom
United States	1.00			
Germany	0.32*	1.00		
Japan	0.64*	0.21*	1.00	
United Kingdom	0.46*	0.56*	0.15	1.00

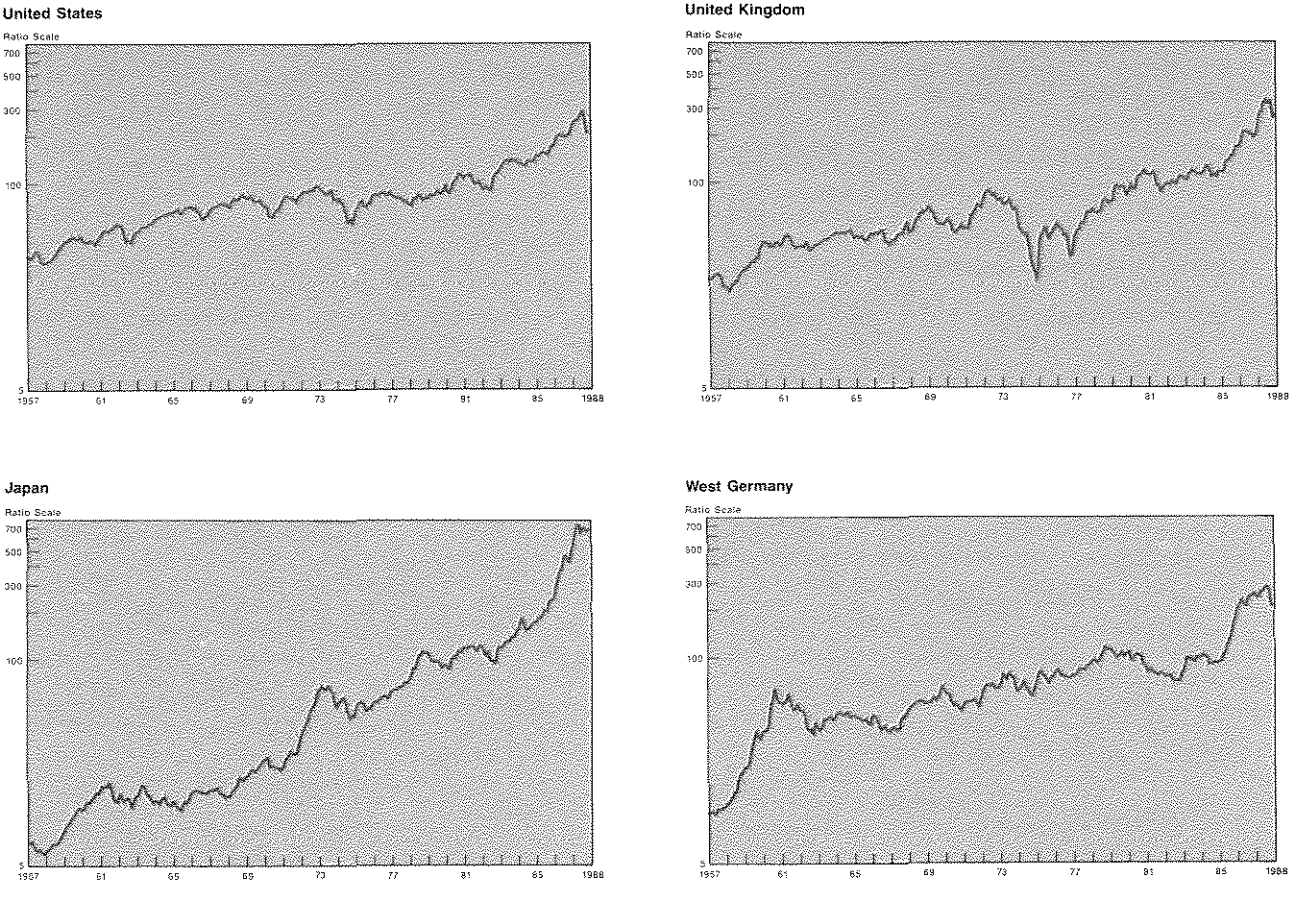
Deleting week of October 19

Country	United States	Germany	Japan	United Kingdom
United States	1.00			
Germany	0.21*	1.00		
Japan	0.28*	0.22*	1.00	
United Kingdom	0.46*	0.36*	0.12	1.00

*Significantly different from zero at 5 percent level.

Chart 3

Stock Price Indexes (monthly averages, 1980 = 100) in terms of dollars



cades, substantial decreases in the market indexes are not uncommon. For example, stock prices in the United States decreased by relatively large amounts in several months: the index decreased 12.0 percent in June 1962, 11.6 percent in May 1970 and 10.5 percent in September 1974. The decrease in October 1987, on a monthly average basis, was 13.3 percent. Large single-month increases are not exactly unknown either: the index for the United States increased 12.1 percent as recently as September 1982.

It also is interesting to note from chart 3 that stock price decreases in the different markets often coincide. From 1957 through 1987, stock prices declined in all four of the markets in 31 months. Coincident increases occur more frequently during the sample: all four stock price indexes increased in 79 months. How many of these would be expected by pure chance? The average proportion of months with an increase is about two-thirds for each country. If two-thirds is the probability of an increase, the joint probability that all of the indexes would increase in any month is 19.75 percent. Given our sample of 371 months, this means that about 73 months of coincident increases are expected. Since one-third is the average proportion of declines for each country, the expected number of coincident decreases is about five. Because the sample contains 110 months of coincident changes while only 73 would be expected by chance, this is longer-term evidence that coincident changes in the indexes occur more often than would be expected by chance.

Relationship Between the Levels of Stock Prices

Is there a long-term relationship between the levels of stock prices during the past 31 years? To answer this, monthly data are used to test for unit roots in the relative stock price indexes. The results of these tests are presented in table 4.[19] The top panel of the table reports the relevant test statistics for the full period. The evidence indicates that the relative stock price indexes have unit roots. With 371 monthly changes, a t-ratio less than about −2.88 would be inconsistent with the null hypothesis of a unit root at the 5 percent significance level. The t-ratios generally are greater than the critical value, an outcome inconsistent with the existence of any normal long-run level of these indexes relative to each other. The test statistics for Germany relative to the United States and for the United Kingdom relative to Germany are, however, less than the critical value. Unlike the others, these results are consistent with the notion that these indexes tend to some normal level.

Table 4

Test Statistics for Unit Roots in Relative Stock Price Indexes: January 1957–December 1987 (logarithms in terms of common currency)

Full period t-ratios

Country	Germany	Japan	United Kingdom
United States	−2.95*	0.73	−2.42
Germany		−0.51	−3.27*
Japan			−0.28

Flexible-rate period t-ratios

Country	Germany	Japan	United Kingdom
United States	−1.87	0.89	−1.58
Germany		0.47	−1.59
Japan			−1.30

*Significantly different from zero at 5 percent level.

The results of the unit root tests from the flexible-rate period, a period characterized by greater financial integration across national borders than the fixed-rate period, uniformly are greater than the critical value.[20] Test statistics using the data from the flexible-rate period are presented in the bottom panel of table 4. These results indicate that in every instance the relative stock price indexes have a unit root. The empirical evidence from the flexible-rate period clearly is inconsistent with the notion that the levels of stock market indexes are linked across countries over long-run periods.

Correlations of Changes of the Indexes

Correlations of the changes in the logarithm of the monthly stock price indexes are reported in

[19]In order to allow for the first-order serial correlation in the indexes due to the Working (1961) effect, we include one lagged change of the relative index in the regressions. We make no adjustment to the critical value for this estimated coefficient.

[20]The beginning of the flexible-rate period is defined as April 1973.

Table 5

Correlations of Changes in Stock Price Indexes: January 1957–December 1987 (logarithms in terms of dollars)

Full period

Country	United States	Germany	Japan	United Kingdom
United States	1.00			
Germany	0.38*	1.00		
Japan	0.31*	0.31*	1.00	
United Kingdom	0.50*	0.33*	0.33*	1.00

Fixed-rate period

Country	United States	Germany	Japan	United Kingdom
United States	1.00			
Germany	0.35*	1.00		
Japan	0.20*	0.16*	1.00	
United Kingdom	0.38*	0.26*	0.17*	1.00

Flexible-rate period

Country	United States	Germany	Japan	United Kingdom
United States	1.00			
Germany	0.42*	1.00		
Japan	0.39*	0.48*	1.00	
United Kingdom	0.56*	0.41*	0.42*	1.00

*Significantly different from zero at 5 percent level.

table 5. Because the sample period incorporates both the fixed- and flexible-exchange-rate regimes, the correlations are calculated for the full 31 years and for each of the two exchange-rate regimes. The full period correlations are relatively high across markets, and all are statistically significant. All but one of the correlations is between 0.31 and 0.38. The outlier is the higher correlation of 0.50 between the United States and United Kingdom.

The evidence from the fixed-rate period presents a rather different picture. Although the correlation between changes in the German and U.S. indexes is about the same as the correlation for the whole period, the other correlations are much smaller. For example, the correlations between the stock price indexes for Germany and Japan (0.16) and between Japan and the United Kingdom (0.17) are about one-half the size of their correlations for the full period. There also is a noticeably lower correlation between the U.S. and Japanese indexes, 0.31 for the full period and only 0.20 for the fixed-rate period.

The evidence from the flexible-rate period suggests that the relationship between U.S. stock prices and the foreign markets is somewhat closer relative to the fixed-rate period. The largest increases in the correlation are between the Japanese and the other indexes, and the largest of these changes is between the German and Japanese indexes, which increases from 0.16 during the fixed-rate period to 0.48 during the flexible-rate period. The correlation between stock price changes in Japan and those in the United States and the United Kingdom also increases substantially, from 0.20 to 0.39, and 0.17 to 0.42, respectively. This suggests that the markets are more integrated in the latter half of the period.[21]

[21]Controls on financial transactions were not suddenly axed with the breakdown of fixed exchange rates; instead, they have been lifted gradually with each passing year. This suggests that, if changes in these restrictions account for at least part of the increases in these correlations, the correlations should be even larger for a period beginning later than 1973. Correlations for 1980 through 1987 provide a tentative way of examining this issue. These correlations provide modest support for this hypothesis, with two of the correlations greater for the more recent period relative to the results for the flexible-rate period in table 5.

CONCLUSION

Are stock markets linked across countries? The levels of stock price indexes in different markets need not move closely together; indeed, they do not. Daily data for three months before and after the October 1987 crash and monthly data for the past 31 years show no evidence that the levels of indexes for the United States, Japan, Germany and the United Kingdom are related. This means that the levels of indexes show no tendency to return to any particular value relative to each other. Thus, using different levels of indexes in various countries as evidence of a link or lack thereof between the markets is unfounded.

The changes in the stock price indexes, at least in the four markets that we examine, generally do move together. The tightness of these links, while real, is not exceptional. For example, the correlation of monthly changes in stock prices in the United States and the United Kingdom is about 0.56 based on data since the beginning of flexible exchange rates. While significantly different from zero, this correlation also is quite far from one.

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