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International Stock Price Movements: Links and Messages

SINCE THE BEGINNING of 1986, the major stock markets have become increasingly internationalized by deregulation. By 1987 some 600 foreign stocks traded in the New York market, and the markets in London, Frankfurt, and Tokyo had also attracted numerous foreign listings. Some analysts worried that the growing international integration of financial markets could help transfer national financial disturbances to other markets.[1] The spectacle, in October of 1987, of nearly simultaneous price collapses around the world was evidence to the point. In this paper we analyze the daily movements in the stock price indexes, from close to close, of the United States, Japan, Great Britain, and Germany during 1986–88, focusing particularly on the correlation of price movements in these, the world's four largest equity markets.

We begin by assuming that stock markets anticipate successfully most events that bear on dividends and discount rates, and that changes in stock prices will be related only to unanticipated events. Dealing with daily changes in asset prices and yields assures this, because more than a normal return can never be expected in efficient markets on financial assets, such as foreign deposits or bundles of shares, or on storable

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1. See Watson and others (1988, p. 45); Bank for International Settlements (1988, pp. 96–97). For recent evaluations of regulatory reform proposals, see Shiller (1988); Perry (1988); Kane (1988).

commodities like crude oil and gold. That normal return is minuscule on a daily basis compared with the daily fluctuations in prices actually observed, leaving almost all of the day-to-day rate of change in asset prices a surprise. Furthermore, these large daily changes, even if due to abrupt revision in expected inflation, need no adjustment for concurrent changes in the general price level facing consumers and producers because average daily product price changes are again minuscule by comparison with daily changes in the prices of financial assets or of individual commodities that are the focus of speculation.

Stock markets can be moved and prices affected by a range of external events that differ in breadth. On the narrow side is a global event whose effect is industry-specific. If an industry, such as air transportation, were affected by the onset of a maintenance or fuel price crisis, the stock prices of major carriers could decline and pull national indexes down everywhere, assuming the event did not benefit other industry groups in the indexes. At the other extreme is a global event that affects entire economies—for example, a money supply impulse by a major country that generates faster growth of monetary aggregates worldwide under a system of management that tries to limit changes in exchange rates. If the rate of inflation expected by investors is not sensitive to such a money supply development, its interest rate and portfolio composition effects would be expected to lead to a universal increase in stock prices.

Purely internal stock market dynamics could also have global consequences if markets are subject to contagion effects—that is, if they are capable of generating sustained momentum without external cause. There are signs of such intrinsic instability. For instance, economic fundamentals could be more successful in explaining national stock price levels relative to each other than the absolute level of any of them.

These conceptually distinct factors can be difficult to disentangle in practice. Because the markets in New York, London, Frankfurt, and Tokyo generally are not open at the same time, their reactions to an isolated news event can be measured only seriatim, in this paper at their successive closes. Even if the event were of equal significance for all four markets, the markets would appear to react sequentially until the last market that was closed when the news broke worldwide closed again. The registration in each market of news of common significance could lead to stock price reactions indistinguishable from those produced by contagion—the action of one market blindly reacting to price movements in the preceding market (net of the first market's own innovation on the previous date), without independent knowledge of fundamentals.

In this paper we apply both technical and fundamental analysis of the correlation of the four major stock market indexes. Technical analysis, which we pursue first, confines itself to stock price movements themselves. Although it cannot discriminate between movements that are based on external news and those that are based on "herd" effects, it can reveal changes in the strength of the echoes between markets and invite conjecture, well short of proof, about the messages being passed from market to market. Second, we use fundamental analysis to determine what economic and financial events, other than the stock price movements themselves, contribute to movements in international stock prices. We outline a model of stock price determination based on low-frequency (monthly or quarterly) data and then interpret its partially reduced form with variables available daily. Among the distributive variables used are changes in interest differentials, exchange rates, and the prices of oil and gold. After this model-based assessment of the influence of fundamentals on the relative rates of change of the national stock price indexes, we consider responses to industry-specific news as another way for changes in fundamentals to be transmitted internationally.

Characterizing Stock Index Data

As shown in table 1, the standard deviation of the rates of change in the stock indexes between January 6/7, 1986, and November 24/25, 1988, was large, consistently over 1 percent *per day* after the crash and not much less before. The crash itself centered mostly on October 19, 1987, but stock price changes from October 15 through October 20 were excluded to distinguish two more stable periods. Except in Germany, stocks trended up, perhaps to a bubble premium, about 0.1 percent each trading day before October 13/14, 1987, but ceased to rise consistently after October 21/22 of that year although the trend was still positive in Japan. For each market, the minimum and maximum show a range that is generally much wider than expected given the standard deviation and number of observations. Indeed, the distribution of the rates of change in national stock price indexes proved strongly leptokurtic except, before

Table 1. Daily Rates of Change in Stock Price Indexes of Japan, Germany, Great Britain, and the United States, before and after the October 19, 1987, Stock Market Crash[a]

Percent

	Japan		Germany		Great Britain		United States	
Statistic	*Before crash*	*After crash*	*Before crash*	*After crash*	*Before crash*	*After crash*	*Before crash*	*After crash*
Standard deviation	1.15	1.12	1.25	1.57	0.84	1.18	0.93	1.34
Mean	0.16	0.06	−0.01	−0.03	0.11	−0.02	0.08	0.01
	(3.08)	(0.88)	(0.20)	(0.36)	(2.94)	(0.34)	(1.73)	(0.13)
Minimum	−4.72	−5.18	−5.67	−7.38	−2.62	−7.15	−4.77	−8.64
Maximum	4.42	6.82	3.90	6.72	2.19	4.12	2.63	4.79
Skewness[b]	−0.22	0.22	−0.33	−0.60	−0.40	−1.35	−0.61	−1.31
Kurtosis[c]	2.35	8.24	1.17	5.67	−0.08	7.53	2.07	8.35

a. The unit of measurement is the change in the natural logarithm of the FT-Actuaries stock price index times 100. The FT-Actuaries World Indices are jointly compiled by the Financial Times Limited, Goldman, Sachs & Co., and County NatWest/Wood Mackenzie in conjunction with the Institute of Actuaries and the Faculty of Actuaries. Except for weekly data used in the industry analysis toward the end, all indexes analyzed in this paper are taken from this source. The period before the crash of October 19, 1987, extends from January 6/7, 1986, to October 13/14, 1987, for a total of 462 observations. After the crash there are 287 observations from October 21/22, 1987, to November 24/25, 1988. Observations during the week surrounding the crash were excluded to prevent extreme outliers from dominating the statistical results reported. Numbers in parentheses are absolute t-statistics.

b. For samples containing at least several hundred observations (n) the variance of the coefficient of skewness independent of the original units is $6/n$, making absolute values of skewness in excess of 0.22 (0.29) significant at the 5 percent level with 462 (287) observations. Negative skewness indicates a distribution skewed to the left (heeling to the right) relative to the normal distribution.

c. The variance of the comparable measure of kurtosis is $24/n$, making absolute values of kurtosis in excess of 0.46 (0.58) significant at the 5 percent level with 462 (287) observations. Positive kurtosis (leptokurtosis) indicates a distribution both more peaked and fat-tailed than the normal distribution.

the crash, in Great Britain. Furthermore, since negative outliers tended to be more pronounced than positive extremes, distributions were skewed to the left significantly in all countries except Japan. Skewness of this sort is not likely to be a fundamental feature of stock price data because there is no tight upper limit on their potential level at any one time. On the other hand, too many very small, together with too many very large, deviations relative to the normal distribution are entirely characteristic of financial asset prices, including stock prices. Indeed, the entire distribution may be composed of heteroskedastic episodes if periods of relative calm alternate with periods of turbulence.[2]

More broadly relevant though they may be, deviations from a normal distribution are taken into account in this paper only in testing whether the stock price series follow a random walk. Mean-reverting, or nonrandom, behavior of stock prices over the long run may be found in heavily

2. See Dickens (1987); Schwert and Seguin (1988).

time-averaged data, but daily data need not show it.[3] Hence, financial data measured at high frequency are commonly described as random walks with trends in their means. To test whether this maintained hypothesis fits the data used here, we allow for constant trends (a) separately in each of the four logarithmic stock price index series, generically called S, before and after the crash. The model used to test for a random walk in these series provides for the possibility of serially correlated disturbances, whose degree of autoregression is represented by $-1 < \rho < 1$. Disturbances, u, will be viewed as nonstationary if b, the coefficient on S_{-1}, is not significantly different from 1 in

$$(1) \qquad S = a + bS_{-1} + \rho u_{-1} + \epsilon.$$

The trend-stationary alternative tested against this difference-stationary null is obtained from equation 1 after adding (deducing) a time trend, t, to allow for the drift term included (through a) before:

$$(2) \qquad \Delta S = (1-\rho)a' + (b-1)(1-\rho)S_{-1} + \rho b(\Delta S_{-1}) + ct + \epsilon.$$

Rejection of the random walk in favor of b significantly less than 1 at the 5 percent level would require a certain F-type test statistic, known as ϕ_3, to exceed the critical value of 6.34 when there are at least 250 observations.[4] Before the crash, the random walk hypothesis can never be rejected though ϕ_3 is very close to the limit for both the United States and Germany.[5] After the crash, however, *all* ϕ_3 values exceed 6.34, and do so by a substantial margin for all countries except Japan.[6] In addition the coefficient on the past rate of change, ΔS_{-1}, which is ρ under the maintained hypothesis ($b = 1$), was between 0.11 and 0.18 and statistically

3. A survey of the evidence is given in De Bondt and Thaler (1989, pp. 189–202). While these authors tend to view the bulk of the evidence as suggesting that there is this anomaly from the viewpoint of efficient-markets theory, others have since questioned whether mean reversion of stock prices is a fact of the post–World War II data. See, for instance, Kim, Nelson, and Startz (1988).

4. See Dickey and Fuller (1981, pp. 1063, 1070).

5. The ϕ_3 statistics for the four countries before the crash were 5.16 (Japan), 6.27 (Germany), 2.66 (Great Britain), and 6.32 (United States). Further tests for successive pairs of these markets showed them not to be "cointegrated," meaning that the nonstationarity in each could not be attributed to a common factor.

6. The values of the test statistic ϕ_3 for the four countries after the crash were 7.94 (Japan), 35.01 (Germany), 16.11 (Great Britain) and 16.82 (United States). For perspective, the probability of a value *smaller* than the unit root exceeds 99 percent for values greater than 8.43.

Table 2. International Timeframe of Regular Stock Market Sessions[a]

Item	Tokyo	Frankfurt	London	New York
Market session				
Local time	9:00–11:00 13:00–15:00	11:30–13:30	9:00–17:00	9:30–16:00
Greenwich mean time	0:00–2:00 4:00–6:00	10:30–12:30	9:00–17:00	14:30–21:00
Local time equivalent				
Noon Tokyo	12:00	4:00	3:00	22:00[b]
Noon Frankfurt	20:00	12:00	11:00	6:00
Noon London	21:00	13:00	12:00	7:00
Noon New York	2:00[c]	18:00	17:00	12:00

Source: *The World Almanac and Book of Facts,* 1988, and authors' applications.
a. After-hours trading in London and the "telephone bourse" operating in Frankfurt before the official 11:30 opening of its stock market are not considered. Variations due to daylight saving time are ignored also.
b. On the date previous to the date at noon in Tokyo.
c. On the date following the date at noon in New York.

significant for all countries before the crash. This indicates that, in some countries at least, stock prices had short runs, efficient-markets theory notwithstanding.[7] Excluding bubbles, that theory implies that markets should react only to news that arises after their previous close and not to their own rate of change on a previous date.

Temporal Links between National Stock Price Averages

The stock market's responses to news on a given date surface at "brokers' hours" from east to west, crossing an international date line out in the Pacific halfway around the globe from the Greenwich meridian. Internationally trained readers may forgive us for spelling out the details.

Each new date begins at the western side of the international date line and expires 48 hours later at the eastern edge of that line. Differences in local times at any given date and moment thus can range up to 24 hours. Table 2 makes it plain to see how markets must be sequenced on a given date in the two types of analysis that follow, though, of course, no *absolute* "before" or "after" can be attributed to countries around the globe. Specifically, the Greenwich mean time line in table 2 shows that there is no overlap between Tokyo and London or Frankfurt, and that

7. This preliminary result is taken into account in reporting a moving-average process of order greater than three in table 3, later in this paper.

Frankfurt opens after, but closes before, London and does not overlap with New York. However, London overlaps with New York for two and a half hours. All these stock exchanges are open Monday through Friday, except on certain national holidays. In addition, the Tokyo market is open for the first session (9:00–11:00 A.M.) on Saturdays, except on the second Saturday and (since August 1986) the third Saturday of each month. However, Monday's change in stock prices is calculated from Friday's to Monday's close, as in all other markets.

The second feature of the data that, judging by a voluminous literature, could be of some importance for daily stock price movements within and between countries relates to day-of-the-week, weekend, and holiday effects.[8] Recurring abnormal holding-period returns, for instance over weekends (from Friday's close to Monday's open) or on the trading day before or after a national holiday, constitute the focus of this literature. In the present samples, however, creating one dummy each for Monday through Thursday and one for any day before, during, or after a holiday showed only one barely significant effect: a negative weekend-cum-Monday effect (from Friday's to Monday's close) in the United Kingdom after the crash.[9] For other countries even the signs were prone to change, as from positive insignificant before to negative insignificant after the crash for Thursdays in the United States and in the opposite direction for Wednesdays in Japan. Not surprisingly, the hypothesis that all day-of-the-week dummies jointly are zero could never be rejected (by an F-test) at the 5 percent level. The before-holiday and after-holiday dummies were statistically so weak in all periods and countries that no similar test even seemed necessary. Whatever older samples may have shown no longer appears a settled feature of the data.[10] We therefore ignored all

8. Recent articles with extensive bibliographies are Miller (1988); Dyl and Maberly (1988); and Pettengill and Jordan (1988).

9. Stock price index values are simply repeated from the most recent close to prevent individual national holidays from interrupting the uniformity of series in the multicountry source followed. As a result of this convention, the coefficient of the "on holiday" dummy is necessarily equal to the value of the constant in the individual country's regression with sign reversed to predict (or "dummy out") the zero price change artificially created for its holidays.

10. This conclusion echoes that of Levi (1988). However, because index returns are calculated simply as the daily change in the logarithm of stock price averages without adjusting for dividends, some systematic element could remain even in perfectly efficient markets without transaction costs if ex-dividend dates are concentrated on Mondays. On this see Phillips-Patrick and Schneeweis (1988).

"calendar" or "seasonal" effects in the remainder of this study while remaining attentive to details of timing.

Technical Analysis

Unable to discriminate between stock price movements due to external events and those due to herd effects, technical analysis initially retreats to the position that "news is what news does," that is, move markets. If stock prices change from the close of one trading day to that of the next, they must be expected to stay there in efficient markets if one disregards the small rates of return required per day. Had stock prices been expected to change right back, they would never have moved in the first place. Hence, the response to news will be modeled as a random walk later in this section.

Consider how such news works its way around the globe and how it is augmented between closings of successive markets. After a day of calm, a global news event, generated and first reported shortly before 3 P.M. Tokyo time, changes the closing stock price average there by j percent. It is then 7:00 A.M. in Frankfurt. Its stock market will close six and one-half hours after Tokyo, capturing news of market effect g, originating during this time, and receiving news reflected in j from the Tokyo close. When Frankfurt closes, it is 12:30 P.M. in London, whose exchange has four and a half more hours before its 5:00 P.M. close for news with effect b to gather. At the same time London reprocesses j and g already contained in the Frankfurt close. By the time London closes, it is noon in New York. New York then reprocesses j, g, and b, which are constituents of stock price average changes recognized either indirectly from the London close or directly from the markets that were first to close on the respective news installments. New York may also contribute to the last of these news installments, measured by b, because New York morning trading overlaps late afternoon trading in London. Thereafter, over four hours, New York adds a, which is the net market weight of news (and noise) arising while its stock exchange is the only one of the four open.

That is the full flow of daily news that can affect any market. For when the Tokyo market closes, nine hours after New York, being first to receive news measure j_{+1} originating during this time, component j_{+1}

replaces j, which was already reflected in Tokyo's previous close. Because technical analysis tends to assume that changes in stock prices *are* the news, j_{+1} becomes known only at the close of the Tokyo stock market as the residual change in the Tokyo stock price average after allowing for the effects of g, b, and a on the previous date.

Absent stock price smoothing through inventory change by specialists or others obligated to maintain continuous markets, the only news that could change the closing stock price average in any country from its previous level is that of the past 24 hours. Markets will under- or overreact to individual news releases or to movements in prior markets, but not systematically, in a way that speculators could expect to find profitable to exploit.[11] At least this is so in efficient markets without privately held inside information if clarification of news or confirmation of rumors, which may require time, is itself treated as news.

During a 24-hour day, the four markets share unequally the hours during which each first reflects news. Tokyo gets nine hours, Frankfurt six and a half, London four and a half, and New York four hours of original intake based on differences in their global closing times. However, news intensity may well vary predictably during each 24-hour period, being greatest, in all probability, in the time zones of the London and New York markets or during their period of overlap. While some stock markets are more likely to lead the way than others, all four could be (or become) important calibrators of global news and sources of contagion as modeled below.[12]

We are now ready to specify the general processing system on which constraints will be placed later to make it empirically tractable. Using capital letters J, G, B, and A to represent the logarithms of the FT-Actuaries World Indices for Japan, Germany, Great Britain, and the United States of America, respectively, we assume that each index

11. Appearances to the contrary can be due to insufficient turnover to keep prices on all the stocks in an index current at closing time. For instance, Stoll and Whaley (1989, p. 12) reported that in 1986 the average time delay between the last trade and the market close was almost 20 minutes for all stocks listed on the New York Stock Exchange.

12. The Frankfurt stock exchange has yet to take advantage of its time zone before London since its short trading hours currently are nested within those of the London market. As long as those short hours persist, Frankfurt will never have exclusive "first crack" at the news during any 24-hour period, and this makes representation in its stock exchange dispensable for most global trading networks.

follows a random walk. The possibility of drift is ignored for now so that day-to-day change is attributed solely to innovations. Subsequently we add constants, which could reflect stable national differences in required rates of return over the period and stand for "expected" exchange rate changes, minuscule though they are on a daily basis compared with actual changes. We use lowercase letters to identify the effect of global news in the country whose stock market first processes this news. The information contained in the foreign stock price change is then reappraised in each of the three national markets functioning thereafter. Still unprocessed global news events furthest removed from the time of operation of any market are listed first in the information flow arrangement below. Underlying news or market events (the starred latent variables therein) are observable through the movement in stock price averages only with random error, which is assumed to be normally distributed, that is, $e = N(0, \sigma_e^2)$. Hence, the stock price innovations themselves could be some combination of signal and noise for other markets. Variables recorded on the preceding *date* less than 24 hours ago elsewhere are indicated by subscript (-1) in the four-equation system that, once under way, would be perfectly recursive.

$$(3) \quad J - J_{-1} \equiv \Delta J = \iota_1 g_{-1} + \iota_2 b_{-1} + \iota_3 a_{-1} + j, \quad j = j^* + e_j;$$

$$(4) \quad G - G_{-1} \equiv \Delta G = \gamma_1 b_{-1} + \gamma_2 a_{-1} + \gamma_3 j + g, \quad g = g^* + e_g;$$

$$(5) \quad B - B_{-1} \equiv \Delta B = \beta_1 a_{-1} + \beta_2 j + \beta_3 g + b, \quad b = b^* + e_b;$$

$$(6) \quad A - A_{-1} \equiv \Delta A = \alpha_1 j + \alpha_2 g + \alpha_3 b + a, \quad a = a^* + e_a.$$

While the system above could be interpreted if the foreign (Greek-letter) coefficients were known, these coefficients cannot be estimated directly without imposing additional constraints. To obtain a point of reference, we will start with an extreme set of identifying restrictions. If there were no errors and all the news were of equal global market impact, all the Greek-letter coefficients would be 1, and j would cut diagonally across the system, unaltered and undiminished, as would g, b, and a, with or without lag. Any market would then appear to replicate the preceding market's movement, net of its own innovation on the previous date and plus its innovation on the current date, simply because the market closing nearest in time contains all the foreign innovations previously still unprocessed. In that special case of *equal global market* *impact of news,* which we will use as our universal reference or comparator for subsequent specifications and results, equation 6, for instance, would become:

$$(6') \qquad \Delta A = j + g + b + a = \Delta B - a_{-1} + a.$$

This equation has two possible interpretations. The one we favor and refer to most frequently is a global random walk. If one market rises, all go up for reasons analogous to the law of one price, though the increase can be registered in other markets only later because they do not operate all at the same time. The analogy with homogeneous auction markets is as follows: if the Tokyo and Zurich gold markets were both open at the same time, the price of Tokyo gold could not be appreciably different from that of Zurich gold. If the price of gold rises in Tokyo, it would have to rise equally in Zurich. If these markets do not overlap, such equality of price movements is not immediately visible since arbitrage does not apply. It remains true, nonetheless, that any innovation in the Tokyo market is immediately incubated in the Zurich market on the same date; contagion would have nothing to do with it. This second possibility, contagion, can apply only when things that are not alike and not subject to the same fundamentals are treated as if they were. Whether the reference model is more descriptive of a global random walk on four legs, than of contagion, therefore depends on one's judgment, say, of whether the most important thing about Japanese stocks is that they are equity claims or that the claims are on Japanese companies.

Allowing for More Differentiated Impact of News

The reference equation above was derived on the assumption that responses to a given news composite, for instance to j, the news composite first measured in the Tokyo market on a given date, are the same as in Tokyo in all other markets by the time of their first subsequent close. In fact, however, the innovation in the Japanese market may have a country-specific component that is "noise" for the rest of the world. This is what the distinction between the observed rate of change, j, and its unobserved global signal component, j^*, tried to hint at in the system of equations above. Markets closing after Tokyo that try to infer j^* from

j would normally have to put a coefficient of less than 1 on j.[13] The implication is that the foreign (Greek-letter) coefficients on the observable innovations, j, g, b, and a would be expected to be below unity in the system of equations 3 through 6.

A second consideration applies even if the news is entirely free of noise and is global in its implications. Take, for instance, an increase in the U.S. dollar price of crude oil or gold. Events like these would not affect all major countries equally. Rather, stock exchanges in oil-exporting and oil-importing countries, say Great Britain and Japan, would be expected to react in an opposite way, and international uncertainties that drive up the price of gold could lead to a turn to the U.S. market alone. If news is not only global but continuously updated, like news on gold and oil prices, only its latest reading in any major market will be of particular concern. On the other hand, such global news as may be created by major incidents in the Persian Gulf or Poland is cumulative and not continuously superseded. It may therefore preoccupy each major market in turn in its own way. At the same time, in deciding what to make of such events for pricing stocks, markets will necessarily have to look for guidance to prior markets in which the force of the event could be calibrated already. New York, for instance, might well assume that Tokyo can best interpret what trouble with oil supplies from the Persian Gulf might do to the Japanese economy and, hence, to a degree, to the world economy. On the other hand, New York would not be nearly as interested in how gold closed in Tokyo since there are more current readings available from the European markets each trading day. The empirical question implied by all this is how markets react to news that transpired in earlier markets and whether they react more to innovations in those markets that closed most recently.

To address this question, a particular set of restrictions was imposed on the original system of equations 3 through 6. To allow that system of

13. Least-squares inference of j^* from j involves solving the regression equation $j^* = aj = a(j^* + e_j)$, where a is to be conceived of as the ratio of the variance of j^* to the sum of that variance and of the random error term, e_j. This establishes that a would be at most equal to 1 if the stock market impact of j^* were the same in all countries. News that is specific to countries other than Japan could first arise during the Tokyo time zone without being reflected in its market. However, news released during the first-time response period of each market, from the most recent close of another market to its own close, generally will have a higher admixture of local content for that market than news released at other times.

otherwise not separately observable innovations to be estimated, we now assume that all coefficients are the same vertically—sorted by subscript. This assumption specifies equality of expected effect for the same degree of remoteness from markets closing earlier in the temporal chain above. For instance, j news—that is, the Tokyo market's response to news that broke in its time zone—would have the same expected effect on the subsequent London market per unit of j as g news on New York, there being another market in between each. However, b news could have a different (presumably greater) effect on New York than g news per unit, because London's close is closer to New York's than Frankfurt's is. The idea is to test whether, for good reason or not, the effect of news diminishes or ebbs predictably as news is registered in market after market once around the globe, always traveling westward by registration though globally communicated almost in an instant. Of course, if news is partly revisionist or superseding (as for news on gold prices), it would not be surprising if it were taken disproportionately from the most recent market.

The loss of country specificity produced by stacking and now requiring the Greek-letter coefficients in the original system of equations 3 through 6 to be the same by subscript allows any of these equations to be represented by the third-order moving-average (MA3) process:

$$\Delta S = -\theta_3 z_{-3} - \theta_2 z_{-2} - \theta_1 z_{-1} + z. \tag{7}$$

The variable z refers to market innovations in the current and preceding time zones. If the change in the logarithm of a national stock price index from close to close, generically called ΔS, happened to refer to the rate of stock price change in New York, then ΔS would equal ΔA. Furthermore, z_{-3} would be j in equation 6, and $-\theta_3$ would be its coefficient α_1 $(= \iota_1 = \gamma_1 = \beta_1)$ under the current set of restrictions. Clearly, if that coefficient and the coefficients on z_{-2} $(=g)$ and z_{-1} $(=b)$ were all unity, the reference model, equation 6′, would result.

Identification tests indicated that additional explanatory power might be gained by allowing for short runs. Consequently, an MA4 process was estimated also by adding z_{-4} with coefficient $-\theta_4$ to the regressors in equation 7, where z_{-4} is the innovation in the same geographic market as z but on the previous date. There would be no reason for day-to-day correlations of the same country's data in efficient-markets theory. The reference model, for instance, that was based on that theory and on the assumption of news of equal global impact would have implied that $-\theta_1 = -\theta_2 = -\theta_3 = 1$ and $-\theta_4 = 0$.

The results in table 3 generated by this model for the periods before and after the crash show that market effects of news innovations ebb somewhat from maximum levels of 0.12 and 0.42, respectively, as they course through the succession of foreign markets for the first time. By contrast, the coefficient on the lagged own innovation, $-\theta_4$, averages 0.12 over both periods. The coefficient of the most recent innovation, $-\theta_1$, is nearly always greatest. Nevertheless, if something happens to Tokyo, almost a third of that ($-\theta_3$) may be expected to arrive in New York under the postcrash regime, even though there are two major markets operating in between. News fade is not as great from market to market as might have been expected. The reason could be that much of the content of the news first captured in the most distant time segment (which would be Tokyo in relation to New York on the same date) is substantive and not superseded by further news releases following the close of its market. It could also be that composition and thrust of complex news events are difficult to infer, except by considering the reaction of several markets, or that contagion, contrary to its name, can be caught not just from the market that is closest.

More striking than news fade is the finding that the reaction to foreign time-zone innovations ($-\theta_1$ through $-\theta_3$) has tripled, having risen from about 0.1 before the crash to 0.3 since the crash.[14] The increase from precrash levels was significant by a Chow test. To see whether the new regime endured over the postcrash period, we arbitrarily divided that period in half. It turned out that sensitivity to foreign markets from precrash levels increased significantly more in the first half of the sample period after the crash than in the second, but it remained strikingly higher throughout. Next we investigated whether the partial overlap between some markets affected this result. Table 4 shows it to be robust if either

14. Increased volatility after the crash could have raised contagion and the covariances of the rates of return among different stock markets, in the view of King and Wadhwani (1989). However, according to another paper presented at the same conference, volatility returned to low precrash levels quickly; see Schwert (1989). Nevertheless, international stock return covariances have remained significantly higher since the crash than they were before, even in the second half of the postcrash period distinguished in table 3. Traditional recommendations for international portfolio diversification, like those summarized by Tapley (1986, pp. 41–58) from before the crash, thus need to be reconsidered.

Table 3. Stock Price Responses to Innovations in Prior Markets[a]

	MA3				*MA4*			
		After crash				*After crash*		
Lagged error[b]	*Before crash*	*Full period*	*First half*	*Second half*	*Before crash*	*Full period*	*First half*	*Second half*
Innovation in first prior market $(-\theta_1)$	0.122	0.395	0.445	0.278	0.122	0.420	0.474	0.283
	(5.21)	(14.00)	(11.40)	(6.68)	(5.25)	(14.25)	(11.36)	(6.77)
Innovation in second prior market $(-\theta_2)$	0.088	0.275	0.265	0.307	0.106	0.307	0.294	0.335
	(3.75)	(9.33)	(6.34)	(7.41)	(4.57)	(10.05)	(6.78)	(7.77)
Innovation in third prior market $(-\theta_3)$	0.037	0.301	0.358	0.143	0.063	0.329	0.387	0.179
	(1.60)	(10.64)	(9.15)	(3.42)	(2.69)	(10.77)	(8.93)	(4.15)
Lagged own innovation $(-\theta_4)$	...	...	...	...	0.137	0.095	0.076	0.090
					(5.93)	(3.22)	(1.83)	(2.13)
Summary statistic								
$\bar{R}^2$	0.03	0.27	0.30	0.17	0.04	0.27	0.31	0.18
Durbin-Watson	1.99	1.95	1.94	1.98	1.99	2.00	2.00	1.99
Q	146	170	113	53	113	159	110	51
k[c]	123	96	69	66	122	95	68	65

a. The form of the equation estimated is 7. The dependent variable is the change in the natural log of the FT-Actuaries World Indices. Three and four lags are used for the third- and fourth-order moving-average process, respectively. The period before the crash includes January 6, 1986, through October 14, 1987, for a total of 462 observations. The first half of the postcrash period includes the 144 observations from October 21, 1987, through May 10, 1988, and the second half of the postcrash period includes the 143 observations from May 11, 1988, through November 25, 1988. The coefficients of the innovations are identified as $-\theta$ in equation 7. Numbers in parentheses are absolute t-statistics.

b. The series was estimated with a constant although the constant proved minuscule on account of each country's "rate of change in stock price average" series having been detrended individually prior to pooling by subtracting the mean rate of change before and after the crash.

c. This number indicates how many of the first residual auto-correlations were used to calculate the Q-statistic here. With values of k ranging from 65 to 123, the hypothesis that the residuals are white noise would be rejected by the χ^2 – test at the 5 percent level if Q exceeds k by at least 31 percent and 22 percent, at the low and high values of k respectively. The hypothesis could not be rejected for the period before the crash and the second half of the sample period after the crash.

Table 4. MA2 Estimation of Stock Price Responses to Innovations in Two Prior Markets after Dropping Frankfurt or London from the Set of Four Markets[a]

	Without Frankfurt				*Without London*			
		After crash				*After crash*		
Lagged error	*Before crash*	*Full period*	*First half*	*Second half*	*Before crash*	*Full period*	*First half*	*Second half*
Innovation in first prior market ($-\theta_1$)	0.140 (5.22)	0.364 (11.03)	0.379 (8.21)	0.340 (7.06)	0.095 (3.53)	0.290 (9.11)	0.313 (7.06)	0.208 (4.46)
Innovation in second prior market ($-\theta_2$)	0.088 (3.27)	0.254 (7.67)	0.292 (6.32)	0.133 (2.74)	0.074 (2.75)	0.363 (11.40)	0.395 (8.88)	0.279 (5.99)
Summary statistic								
$\bar{R}^2$	0.03	0.18	0.19	0.13	0.02	0.19	0.21	0.12
Durbin-Watson	1.97	1.97	1.97	1.97	1.98	1.96	1.96	1.95
Q	153	127	90	45	132	143	98	50
k	109	85	58	58	109	85	58	58

a. The dependent variable is the change in natural log of FT-Actuaries World Indices. Dropping Frankfurt allows checking whether removing the least important market affects the results; dropping London and retaining Frankfurt eliminates any temporal overlap that could have affected the results with four markets reported in the previous table. While the distinction between before and after the crash remains highly significant, unlike in table 3, the further distinction between responses in the first and second half after the crash is not statistically significant at the 5 percent level. For definition of periods before and after crash, see table 3, note a.

the Frankfurt or London markets are dropped from the basic (nonautoregressive) system. The impression of news fade, on the other hand, does not survive without London because $-\theta_2$ becomes larger than $-\theta_1$ after the crash.

Principal News Components

So far we have discussed news as if it had a single dimension that could readily be measured and focused on by the stock market—news being perhaps no more than the stock price movements themselves. If news is an unexpected change not just in a single datum but in a composite of underlying data or events that are difficult to weigh together, each country's reaction to news, and not just its first-time calibration, such as j or g, would have to be considered to clarify its content. For instance, assume there are up to four independently distributed news factors, the same as the number of national stock price average series. Since these four factors must necessarily account for the entire variation in principal components analysis, the fourth factor might be viewed as a residual category or as not substantive. The other factors, however, capture influences shared by two or more countries to varying degrees.

Table 5. Principal Components Analysis of Daily Rates of Change in the FT-Actuaries Stock Price Indices of Four Major Countries[a]

Country	Principal components			
	1	*2*	*3*	*4*
		Factor loading before crash[b]		
Japan	0.513	−0.455	−0.728	−0.004
Germany	0.439	−0.681	0.585	0.035
United Kingdom	0.682	0.373	0.104	−0.621
United States	0.671	0.415	0.068	0.611
Eigen-values	1.371	0.983	0.887	0.760
Percent variance explained[c]	34.27	24.57	22.17	18.99
		Factor loading after crash[d]		
Japan	0.623	−0.643	0.422	−0.144
Germany	0.780	−0.350	−0.447	0.265
United Kingdom	0.829	0.360	−0.232	−0.359
United States	0.722	0.518	0.384	0.250
Eigen-values	2.205	0.934	0.579	0.283
Percent variance explained[c]	55.12	23.34	14.47	7.07

a. The data used are identified in the first note to table 1.
b. January 6/7, 1986–October 13/14, 1987.
c. Percent of variance of stock indexes explained by each principal component.
d. October 21/22, 1987–November 24/25, 1988.

If the first and largest component can be identified with the most global disturbances, then the impact and processing of these disturbances should be more equal among major industrial countries the greater international cooperation among them.[15] Table 5 shows that the factor loading of the first component is indeed positive and of similar size for the four countries, suggesting not only globality but also that burden sharing, as opposed to beggar-thy-neighbor policies, could have prevailed among them.[16] Furthermore, this factor loading was consistently larger after than before the crash, with the percentage of the variance of

15. The maximum number of components that may be estimated is equal to the number of equations. The content and context of those equations may help reveal what these components may capture, but there is no obvious identification. However, it is natural to think of the component explaining the largest percentage of the time series behavior, that is, variance, of stock price changes as reflecting news whose import is most widely shared, or global. See Saunders (1986, pp. 235–45). Similar interpretations of the first principal component as a measure of the linkage among national stock market indexes through a common factor are found originally in Ripley (1973).

16. Apart from shocks generated by producer cartels, trade restrictions, or tax actions, monetary and fiscal policies can have beggar-thy-neighbor characteristics. See Dornbusch (1980, p. 202); Frenkel and Razin (1986, p. 573).

daily stock price changes explained by the first principal component rising by more than half, from 34 percent to 55 percent. The importance of country-specific shocks and redistributive shocks thus has declined relative to common, or cooperatively handled, shocks and policy innovations. Such a development could have made changes in the portfolio demand for equities correlate much more closely across the world's largest stock markets.

While all the technical analyses attempted in this part point to increased international correlation, the question is what fundamental or policy changes could have produced it. In particular, can the changed behavior of high-frequency economic data since the stock market crash of October 19, 1987, help explain the increased correlation of stock prices between countries? Of course, if what investors have learned from the crash is that equally "reasonable" stock market valuations can be found to lie as much as 20 percent apart from one day to the next without benefit of change in fundamentals, increased international cohesion of daily stock price movements might reveal something else. It might reflect the perceived imperative to pick up early on any sign of developing stock market momentum—those episodes that contribute to fat-tailed distributions remarked earlier—and not to wait for revelation of any fundamental factors that may have caused it.

Fish that live in schools have long learned not to insist on personally identifying a shark or any other reason for flight before they take cover. If we may be allowed to continue this metaphor for a moment, fish prefer to react to each other and to imitate for survival. Whatever fundamentals their behavior accords with can then be determined not in each individual case, or day by day, but only in a broad sweep (of evolution). We turn, therefore, to the issue of which fish can alert the school and discuss the question of market leadership before trying to look into the jaws of fundamentals.

Changing Patterns of Leadership

With markets appearing to react increasingly to each other or to common news, the question arises which markets are particularly important calibrators of news and what may have changed in this regard after the crash. Vector autoregression analysis (VAR) is tailor-made to obtain the impulse responses and variance decompositions desired.

Since the time sequence of markets is not arbitrary, which equation is first depends on where one cuts into the chain. On a given date, Japan is first, or at the top, and the United States last, or at the bottom, with Germany and Great Britain in positions two and three, simply because the Tokyo market is first, and the New York market last, to close. Unexpected innovations in the Tokyo market can only trickle down from there to the other markets, and innovations in these other markets cannot get back to Tokyo on that date, as the previous system of equations 3 to 6 has shown. Conceptually, of course, the lagged innovation reflected in the U.S. market's close of the previous date is no more passé for the Japanese market than the Japanese innovation is for the German market on the same date. We will, therefore, in the table after next, advance the date of the U.S. market to put it ahead of Japan and proceed similarly with the British and German markets to give each a chance to appear at the top of the ordering.

At most one lag should appear in the VAR for efficient markets. While a single lag turns out to be quite sufficient before the crash in the sense that results are not appreciably affected by allowing one more, this changes thereafter.[17] Consistent with the strong rejection of the random walk hypothesis in the daily stock price indexes of all countries for the period after the crash, longer lags have some explanatory power in that period. To standardize reporting for both periods, the results obtained with two lags are shown in table 6. Since almost nothing further is added to, or subtracted from, the response to a sustained impulse equal to one standard deviation of the orthogonalized residuals after three periods, responses to a one-time impulse are shown individually only up to that point.

In the variance-covariance matrices of the residuals themselves (bottom of table 6), the size of all covariances off the diagonal has risen, thus echoing previous findings of increased postcrash interdependence between markets. The variance decompositions (in the middle of the table) similarly show that the percentage of the variance of stock price

17. More precisely, log-likelihood ratio tests using χ^2 statistics with 16 degrees of freedom showed that allowing a second lag (for a total of nine regressors in each of the four equations with constant) did not make a statistically significant difference at the 5 percent level before the crash but did make such a difference after the crash. The actual significance levels were 0.14 and 0.0003, respectively. However, even in the latter case there was no significant further improvement from adding a third lag.

Table 6. Impulse Response Analysis and Variance Decomposition of Daily Rates of Stock Price Changes in Japan (*J*), Germany (*G*), Great Britain (*B*), and the United States (*A*)

		Before crash				After crash			
Item	*Day*	ΔJ	ΔG	ΔB	ΔA	ΔJ	ΔG	ΔB	ΔA
Impulse variable				*Impulse response in first, second, and third day*[a]					
ΔJ	1	1.10[b]	0.07	0.05	0.07	0.96[b]	0.54[b]	0.20[b]	0.30[b]
	2	0.17[b]	0.01	−0.02	0.02[b]	0.09[b]	−0.11[b]	−0.06[b]	−0.01
	3	0.06[b]	0.02[b]	0.04[b]	0.02[b]	−0.17[b]	−0.16[b]	−0.17[b]	−0.28[b]
ΔG	1	0.00	1.19[b]	0.01	0.05	0.00	1.21[b]	0.43[b]	0.18[b]
	2	−0.06[b]	0.15[b]	−0.02	−0.02[b]	0.11[b]	0.01	−0.23[b]	−0.23[b]
	3	−0.02	−0.12[b]	0.01[b]	−0.01[b]	0.00	−0.09[b]	0.00	0.07[b]
ΔB	1	0.00	0.00	0.79[b]	0.20[b]	0.00	0.00	0.93[b]	0.63[b]
	2	0.02[b]	0.01	0.11[b]	−0.04[b]	0.24[b]	0.59[b]	0.23[b]	0.13[b]
	3	−0.11[b]	−0.06[b]	0.02[b]	−0.01[b]	0.22[b]	0.21[b]	0.07[b]	0.07[b]
ΔA	1	0.00	0.00	0.00	0.89[b]	0.00	0.00	0.00	1.01[b]
	2	0.21[b]	0.31[b]	0.23[b]	0.11[b]	0.21[b]	0.41[b]	0.12[b]	−0.03[b]
	3	0.11[b]	−0.02[b]	−0.05[b]	0.02[b]	0.04[b]	−0.07[b]	−0.03[b]	0.02[b]
Variable				*Variance decomposition after three days (percent)*[b]					
ΔJ	3	94.41	0.30	0.98	4.31	85.13	1.17	9.56	4.14
ΔG	3	0.40	93.01	0.26	6.33	14.12	62.11	16.46	7.31
ΔB	3	0.63	0.11	91.20	8.05	5.52	19.13	74.09	1.26
ΔA	3	0.65	0.32	5.01	94.01	10.14	5.30	24.51	60.05
				Variance-covariance matrix of the residuals					
ΔJ		1.21	0.08	0.05	0.08	0.92	0.52	0.19	0.29
ΔG			1.42	0.02	0.06		1.75	0.63	0.38
ΔB				0.63	0.16			1.09	0.72
ΔA					0.84				1.55

a. Impulses are equal to one standard deviation of the orthogonalized innovations in the variables shown on the left. These impulses are equal to the standard deviation of the nonorthogonalized errors, whose variance-covariance matrix is shown in the bottom triangles, only for the variable that is ordered first (ΔJ).

b. Monte Carlo simulations showed impulse responses to be statistically significant at the 1 percent level.

c. Percent contributed to variance of variable on the left. Values sum to 100 percent horizontally.

change still explained by innovations in the own market three periods later has fallen from consistently over 90 percent before the crash to as little as 60 percent since. Going out one more period on account of the redating required to put the U.S., German, and British markets ahead of Japan's, the results in the bottom part of table 7 show this conclusion to be insensitive to ordering: the percentage of the variance in any variable explained by any other remains pegged in a narrow range.

The impulse response analysis, in the top part of table 6, speaks most directly to the question of leadership. It shows first that all markets have become much more sensitive to innovations in Japan (in period 1), but not more sensitive to innovations in the United States (in period 2). In the initial response after the crash, the Japanese market passes almost a third of its impulse to the United States, while only about one-fifth of the U.S. impulse initially reaches Japan. The difference is that maintaining the U.S. impulse adds a little more, leaving an appreciable "permanent" effect on the Japanese market, while the effect of a sustained impulse in Japan on the U.S. market proves ephemeral. The first of these results stands up under differences in ordering as shown in the column indicating the response of ΔJ to impulse variable ΔA after the crash in table 7. However, the degree of retention of Japanese stock price impulses in other markets after four periods is quite sensitive to ordering. Furthermore, even if impulse responses are quickly reversed so the cumulative response to a sustained impulse of given size would go to zero within a few periods, starting any such impulse could still create turbulence in other markets. More generally, a cumulative impulse response of zero by itself need not indicate the absence of relevant effects on foreign markets if impulses change frequently.

Results before and after the crash show that little has changed with the degree to which foreign markets retain Japanese and U.S. stock market innovations. Only sustained innovations in the British index have a consistently much greater and more lasting effect on foreign markets after the crash than before. The huge expansion and internationalization of the London market that started within the year before the crash undoubtedly has contributed to this outcome. Tokyo, coincidentally or not with its capitalization overtaking that of New York, has increased its signaling effectiveness in the "flash" range. But London appears to have become the primary market for crystalizing more lasting effects that could lie at the level of fundamentals.

Table 7. Impulse Response Analysis and Variance Decomposition for Markets Arranged in Order of Closing with Four Alternative Starting Points for the Trading "Day": Tokyo (J), Frankfurt (G_{+1}), London (B_{+1}), and New York (A_{+1})[a]

Item	Starting point	Before crash				After crash			
		ΔJ	ΔG	ΔB	ΔA	ΔJ	ΔG	ΔB	ΔA
Impulse variable		*Cumulative response after four days*[b]							
ΔJ	J	1.35	0.11	0.08	0.11	0.77	0.13	−0.08	−0.03
	G_{+1}	1.32	0.09	0.04	0.10	0.85	0.39	0.16	0.30
	B_{+1}	1.31	0.10	0.04	0.11	0.86	0.27	0.14	0.31
	A_{+1}	1.34	0.10	0.05	0.11	0.76	0.11	−0.13	0.11
ΔG	J	−0.07	1.18	0.00	0.01	0.07	1.09	0.16	−0.05
	G_{+1}	−0.01	1.19	0.01	0.02	−0.03	1.00	0.11	−0.12
	B_{+1}	−0.09	1.18	−0.02	0.02	0.07	1.10	0.24	0.04
	A_{+1}	−0.08	1.18	−0.02	0.03	0.06	1.05	0.11	−0.03
ΔB	J	−0.12	−0.06	0.95	0.14	0.48	0.78	1.17	0.76
	G_{+1}	−0.23	−0.07	0.93	0.12	0.29	0.73	1.17	0.76
	B_{+1}	−0.23	−0.05	0.94	0.12	0.29	0.64	1.16	0.77
	A_{+1}	−0.13	−0.06	0.93	0.13	0.36	0.57	0.99	0.72
ΔA	J	0.33	0.26	0.20	1.02	0.23	0.34	0.07	0.96
	G_{+1}	0.43	0.26	0.21	1.02	0.22	0.32	0.05	0.95
	B_{+1}	0.41	0.34	0.20	1.03	0.25	0.29	0.06	0.99
	A_{+1}	0.43	0.34	0.30	1.05	0.22	0.33	0.10	0.99
Variable		*Variance decomposition after four days (percent)*[c]							
ΔJ		93-94	0-1	1-2	4-5	83-86	1-4	7-9	4-5
ΔG		0-0	93-93	0-0	6-6	12-15	62-63	14-16	7-9
ΔB		0-1	0-0	91-91	8-9	4-6	16-19	74-76	1-3
ΔA		1-1	0-0	4-5	94-95	7-10	3-6	25-27	60-65

a. Markets are put ahead of Japan on a given date by taking that date and assigning it to markets closing after Japan on the previous date. For instance, to make Frankfurt rather than Tokyo the first market to close on a trading day, with Tokyo retaining the natural date, say of December 7, the Frankfurt, London, and New York data of December 6 are all redated December 7. Then Frankfurt is the first and Tokyo the last market to close on the trading "day" constructed in a way that does not involve changing the natural time sequence but only where one breaks into its progression.

b. The size of the impulse ΔJ is 1.10 and 0.96 before and after the crash if Tokyo is ordered first; ΔG is 1.19 and 1.21 before and after the crash if Frankfurt is first; ΔB is 0.79 and 0.94 before and after the crash if London is ordered first; and ΔA is 0.88 and 1.03 before and after the crash if New York is first. The impulses in any of the variables differ by at most 0.01 from the values shown for each before the crash and by at most 0.02 after the crash, so that they are almost independent of reordering and redating.

c. Range of percentages contributed to variance of variable on the left, given four different starting points.

Temporal Relations in Efficient Markets

So far we have avoided simply regressing the rate of change in each of the major markets on that in the three others. The reason for our reluctance is easy to deduce from the original model, equations 3 through 6. Regressing one market's rate of change at the close of trading on that of the three preceding markets brings in some dated information, information that should have no further effect on the regressand under the hypothesis of efficient markets. It also brings in with the regressors other information that should still have such an effect, but quite possibly more than once. For instance, regressing ΔA on ΔB, ΔG, and ΔJ jointly would cause j to be picked up three times according to equations 3 through 6. It would come once, surrounded with dated information, in ΔJ, then once more, accompanied by g and dated information, in ΔG, and then again, accompanied by both g and b and no dated information other than a_{-1}, in ΔB. Clearly, the latter explanatory variable would be expected to be the strongest for ΔA, while the "earlier" ones, though increasingly freighted with used-up information as one goes back in time, would be partly collinear with it.

Although regressing markets on markets would therefore be an unsatisfactory way to deal with trading in successive time zones, it is interesting to look at cross-correlations between markets at different frequencies and leads and lags. The top two segments of table 8 contrast cross-correlations between weekly data with the same correlations in daily data. Since weekly rates of change in the different national stock price indexes are calculated for periods, Wednesday to Wednesday, that are largely overlapping, information is shared both ways and stock price responses are mutual, flowing back and forth within the observation period. Hence, unlike daily correlations, weekly correlations should not show each market related most closely to its immediate predecessor in the order of closing. And indeed, while the daily data show that correlations are generally much higher along the principal diagonal (giving the correlation of a market with its immediate successor) than above it, there is less evidence of this in the weekly data. Both daily and weekly data suggest once again, however, that cross-correlations are higher after the crash than before. That the gain is more pronounced in daily than in weekly correlations, but from a lower level, may hint that

Table 8. Cross-Correlations between Rates of Change in National Stock Price Indexes, Weekly and Daily on the Same Dates and Daily with Leads and Lags

Variable	Lead or lag	Before the crash			After the crash		
		ΔG	ΔB	ΔA	ΔG	ΔB	ΔA
Weekly[a]							
ΔJ	...	0.16	0.13	0.39	0.56	0.21	0.42
ΔG	...		0.03	0.22		0.40	0.43
ΔB	...			0.49			0.46
Daily							
ΔJ	...	0.11	0.10	0.10	0.48	0.24	0.24
ΔG	...		0.08	0.06		0.53	0.28
ΔB	...			0.24			0.61
Daily							
ΔJ	+2	−0.01	−0.09	0.08	−0.03	0.17	0.11
	+1	−0.02	0.04	0.21	0.27	0.38	0.37
	0	0.11	0.10	0.10	0.48	0.24	0.24
	−1	0.01	−0.02	0.03	−0.03	−0.04	0.00
	−2	0.01	0.05	0.02	−0.12	−0.17	−0.25
ΔG	+2		−0.05	−0.03		0.09	0.01
	+1		−0.00	0.25		0.36	0.42
	0		0.08	0.06		0.53	0.28
	−1		−0.05	−0.01		−0.12	−0.09
	−2		0.02	−0.01		−0.07	−0.06
ΔB	+2			−0.04			−0.02
	+1			0.28			0.17
	0			0.24			0.61
	−1			−0.03			0.04
	−2			−0.01			0.03

a. Weekly rates of change between Wednesday's closing prices were calculated from January 15–22, 1986, to October 7–14, 1987, before the crash for a total of 91 observations and from November 4–11, 1987, to November 16–23, 1988, after the crash for a total of 55 observations using the FT-Actuaries World Indices throughout this part of the paper. Daily rates span the same periods as in earlier tables; see, for instance, table 3, note a.

while there is fundamental news for markets to share, a week is long enough for some of the more contagious daily movements that started after the crash to be particularized.

The bottom part of table 8 allows timing relations between the different markets to be examined further on a daily basis. Leads (+) indicate the next date from whatever date is associated with the markets listed along the top. Hence, correlations between the rate of change in the U.S. market and the Japanese market one date later would be shown on line ΔJ_{+1} in column ΔA for before and after the crash. Similarly, lags (−)

signify that it is one date earlier in the markets shown on the left than in those on top. If time-zone trading occurs in efficient markets, Tokyo's rate of change, ΔJ, for instance, can be influenced only by the news first reflected in the preceding markets on the previous date. Tokyo itself influences all succeeding markets on the same date via *j* news. Taken together this means that ΔG, ΔB, and ΔA would be correlated with ΔJ_{+1} in one direction and with ΔJ ($= \Delta J_0$) in the other, but be uncorrelated with ΔJ at any time and subscript other than 0 and $+1$. Analogous arguments follow for Germany and Great Britain.

Alternatively, adopting a U.S. perspective, we see that its market may be influenced by all the others closing earlier that same date and influence all others on the next date. This again implies that cross-correlations for ΔA can be positive significant with both ΔJ_{+1} and ΔJ, ΔG_{+1} and ΔG, and ΔB_{+1} and ΔB, but not with any other leads or lags of these variables. Both before and after the crash, these expectations are met without noteworthy exception. With 287 observations after the crash, correlation coefficients of 0.12 or more are positive significant at the 5 percent level. Hence, all correlations in the 24-hour range are significant for this period in table 8. We conclude, therefore, that even though we have noticed occasional spillover beyond the sharp 24-hour limits put on measured responses to information by the efficient-markets hypothesis, that hypothesis provides the right general understanding of when things happen in time-zone trading.[18]

Fundamental Analysis

So far in our analysis the content of the news behind stock price movements has remained undefined. News need not even *have* identifiable content: that stock price averages, somewhere in the world, move is news enough. Now we try to identify the causes of change.[19] Our goal

18. Using stock price indexes of 13 major industrial countries, another study, using daily data from 1981 through June 1983, found that most of the documented lead-lag relationships are of one trading day or less and thus not inconsistent with the efficient-market hypothesis. See Schollhammer and Sand (1987, pp. 149–86).

19. To qualify as fundamental, these causes would have to be more than just part of the information set used to form expectations irrespective of the structure of the model. For more on the distinction between bubbles and fundamentals, see Buiter (1986, pp. 564–66), and Dwyer and Hafer (1989).

is to specify variables that could explain some part of daily percentage changes in stock price averages and how such changes are related between countries.

The basic model we have in mind does not deal immediately with daily movements. Instead, it allows for medium-run departures from equilibrium that could extend over several quarters. These involve Tobin's q approaches to investment in plant and equipment, where the level and composition of the capital stock can be brought to desired levels, and q adjusts from the supply side, only gradually. They also involve a Dornbusch-type exchange rate determination process in which expected changes in exchange rates offset the financial advantage otherwise arising from international interest rate differentials. The process implies that commodity prices and the return to absolute purchasing power parity are sluggish. National stock price indexes should diverge when changes in the (real) exchange rate and the interest differential between countries alter competitive conditions and expected returns.

Specifically, the basic model predicts that, contrary to rationalizations of stock price changes frequently heard from commentators in the media, stocks should rise in the country whose currency depreciates relative to that of another country if absolute purchasing power parity is the end point for expectations to stand on.[20] On the other hand, they should fall, as everyone would expect, if the interest rate differential changes as a country's interest rate rises. In fact, in the Dornbusch model without risk premiums, these two types of changes are tightly interrelated. Lower the interest rate in one country through monetary expansion, and its exchange rate will overdepreciate, being expected to return to purchasing power parity through a series of appreciations. These appreciations would offset the negative international interest differentials for as long as they are expected to last and eventually bring interest rates and

20. The prediction is consistent with findings from two-stage least squares estimates for the period from December 1973 to December 1984 for the exchange value of the dollar against major (Group of Seven, or G-7) currencies reported in Bessembinder (1988). However, the end point, purchasing power parity, may not ever have been well supported. One recent conclusion on this is that "the assumption of long-run purchasing power parity—in particular, of time-invariant expectations about the long-run real exchange rate—seems virtually impossible to support statistically, but has not been rejected convincingly by statistical tests." See Isard (1988, p. 188).

exchange rates back to parity. In the meantime, however, lower interest rates would reduce the *required* rate of return on productive capital and combine with a depreciated exchange rate to raise the *actual* rate of return on partly debt-financed capital. A rise in the value of stock market claims to that capital would be the expected result. If, on the other hand, a fiscal contraction, or a spontaneous falloff in aggregate demand, including foreign demand for domestic goods, had contributed to declining interest rates and exchange depreciation, positive effects on stock price averages would not be as certain.

It turned out that the correlation between the change in the interest differential with another country and the change in the corresponding bilateral exchange rate with the dollar was weakly positive and somewhat higher after the crash than before. Instead of being accompanied by exchange appreciation as in the basic model, rising interest rate differentials thus leaned modestly against depreciation, where depreciation is defined positively as a rise in the dollar price of a unit of foreign exchange.[21] This suggests that exchange rates moved first and that monetary policy, at times involving symmetric intervention by the major countries, was then used to counteract this movement to some degree. Hence, if depreciation should come to be viewed as presaging monetary contraction designed to keep exchange rates approximately fixed, it would not need to have the positive effects on stock prices promised by the basic model.

Besides referring to rising interest rates and a falling dollar, U.S. commentators, at least through 1988, regularly blamed gold and oil price increases for declines in the U.S. stock market. From an international perspective, however, oil price increases should clearly be much more negative for potential output growth in Japan and Germany than for that in the United States. News of oil price hikes could thus encourage some portfolio substitution in favor of U.S. equities by foreign holders. Gold price increases could even help the U.S. market by reducing risk premiums required on financial investments in the United States if the United States is viewed as the principal refuge, next to gold, for the

21. Finding an increase in U.S. interest rates to be accompanied by depreciation of the dollar is inconsistent with Hardouvelis's (1988) characterization of the October 1979 through August 1984 period. Thus there may have been a change toward increased cooperation after the end of his estimation period, away from the noncooperative regime that could have ended around the time of the Plaza Accord in September 1985.

world's capital in times of growing global uncertainty.[22] In a world in which deregulated financial claims with variable interest rates have come to provide a rich menu of hedges against inflation, gold is no longer called upon importantly to fill that role. Hence, its price has lost the ability to signal changes in the expected rate of general price inflation. In light of all this, we have no firm expectations on what oil and gold price increases should do to U.S. stocks, but both should be registered negatively in Frankfurt and Tokyo. Oil price increases could very well have been positive for the British stock price index as a whole, in part because of favorable budget effects and their policy ramifications.

Empirical examination of the multilateral determinants of daily stock price change identified in the appendix yielded the following findings. First, exchange depreciation was positive, as the basic model would suggest, consistently only for the German stock market. After the crash, depreciation had a negative association with the U.S. market, a pattern that popular wisdom has come to regard as causal. Second, a widening of a country's interest differential with other countries did tend to be associated with falling stock prices in the United States but not consistently in other countries. In particular, Great Britain's interest differential with other countries grew dramatically in 1988 without depressing its stock market. Third, oil price increases have not consistently depressed stock price averages in any of these countries over the period examined. Indeed, signs have been positive in Great Britain and the United States.[23] And, finally, gold price increases have been consistently negative for stock averages in Europe and Japan but not for the U.S. stock market.

Overall, the results obtained are sharpest for Germany, whose market

22. Pairwise correlations between the rate of gold and oil price change were positive but small both before (0.10) and after (0.19) the crash. Oil price changes and exchange rate changes of the dollar with each of the three other currencies were essentially uncorrelated. However, there was some tendency (evidenced by simple correlation coefficients of 0.2 to 0.3) for the dollar to weaken (the dollar price of foreign currencies to rise) when the price of gold increased while the U.S. interest rate differential with other countries remained basically unaffected by the vagaries of the dollar price of gold. All variables referred to here are identified further in the appendix.

23. Significantly negative effects of oil price changes on real GNP growth in the United States have been reported for earlier periods (1953–84), but effects on stock prices and required return have been less clear (1968–84). See, respectively, Boschen and Mills (1988); Chen, Roll, and Ross (1986).

closes at about the time the daily changes in explanatory variables are determined—that is, afternoon in London or, for oil, at the opening in New York. They are almost featureless for Japan, whose market, one date ahead, closes fifteen and a half hours after the New York market's open, a span during which much can happen. This draws attention to the need for matching information exactly to each market's operating times, something we could not accomplish in the construction of the explanatory variables in the fundamentals model.[24] Once this can be done, there is hope that "the repeated failures to produce good explanatory equations for stock prices using nonspeculative price variables," noted in a 1984 survey, will be supplemented by some successes.[25]

Globalization by Industry?

Unable to link stock price movements consistently with the broad economic fundamentals, we made another attempt to infer what may be driving the different stock markets. Indirect identification of fundamentals in international stock markets may be possible by disaggregating the overall indexes to an industry level in each country. Differences in industry composition, by themselves, can then help account for unequal changes in national stock indexes. In fact, even if movements in industry averages differ only by industry and not by country, the correlation between the rates of change in national indexes can be well below unity on account of differences in industry weights. For the same reason, industry beta coefficients can differ between countries.[26]

INDUSTRY EFFECTS FROM JAPAN TO GERMANY. Mindful of the importance of weighting, we show in table 9 the matches we could make of industry group and subgroup averages in Frankfurt and Tokyo and the weight of

24. Soon there will be no excuse for failing to achieve precise market-to-market matching as data, even on oil price futures, will become available minute by minute through 24-hour trading systems, currently under development, such as Globex.

25. See Fischer and Merton (1984, p. 89).

26. What would be known as the beta coefficient of an industry in financial jargon is equal to the covariance of the rate of change of its index with that of the overall national market index, divided by the variance of the latter. A coefficient of 1 would indicate that an industry average can be expected to share with equal strength in any move of the market. Since the weighted average of all industry betas must be unity, the beta coefficient of an industry would be closer to unity the larger its weight in the respective national stock market, other things being equal.

Table 9. Identification and Weights of Industry Averages in the F.A.Z. 100 and Nikkei 500 Stock Price Indexes[a]

	F.A.Z. class			*Year end weight*		*Nikkei class*		*Weight*
	1987	*1988*	*German industry group*	*1987*	*1988*	*1988*	*Japanese industry group*	*10/31/1988*
(1)	1	1	Banks and insurance	16.63	26.62	49,000	Securities	4.06
(2)	1a	1a	Large banks	9.91[b]	10.53[b]	47,000	Banking	21.97
(3)	1b	1b	Insurance	2.93[b]	12.68[b]	51,000	Insurance	2.09
(4)	2	2	Metal working	8.28	3.88	17,000	Iron and steel	4.97
(5)	3	3	Electrical industry	8.77	11.41	23,000	Electric equipment	9.40
(6)	4	4	Building materials (and construction)	1.76	2.77	15,000	Clay and glass products	1.52
(7)	5a	5	Large chemical combines	21.23	16.40	9,000	Drugs	2.43
(8)	5b	6	Other chemicals	2.75	3.30	7,000	Chemicals	4.21
(9)	5c	. . .	Rubber	1.05	. . .	13,000	Rubber products	0.42
(10)	6	7	Utilities	11.76	6.67	67,000	Electric power	5.18
(11)	7a	8	Automobiles and parts	11.13	15.90	27,000	Motor vehicles	4.07
(12)	7b	9	Machine building	5.68	3.64	21,000	Machinery	1.83
(13)	8	10	Basic materials	3.01	3.60	19,000	Metal products	1.76
(14)	10	11	Commerce[c]	3.06	4.51	43,000	Trade	2.50
(15)	11a	12a	Breweries	0.66	0.47	1,000	Foods	2.49
(16)	12	11a	Transport, mostly air	3.12	1.26[b]	61,000	Air transport	1.12
			All other	1.11	0.83		All other	29.98
Total				100.00	100.00			100.00

a. The weights in the F.A.Z. share index as of December 30, 1987, were published in *Blick durch die Wirtschaft*, January 5, 1988. The index, unchanged since year end 1981, was adjusted as of January 2, 1989, by replacing 24 of the 100 companies in the index. The latter now account for about 76 percent of the value of the shares of all German companies traded on the exchanges. Weights calculated for the revised index as of December 29, 1988, are given in Erich Erlenbach, "24 neue Werte im aktualisierten F.A.Z.-Aktienindex," *Frankfurter Allgemeine Zeitung*, December 31, 1988, p. 17. Weekly data were provided to the authors from July 11, 1986, for most industries, and from April 3, 1987, for some, through November 11, 1988. The F.A.Z. index is a Paasche type index that is adjusted for share distributions or splits but not for cash dividends when stocks go ex-dividend. The weights in the Nikkei 500 were calculated by the authors using industry codes and market values of the 500 companies furnished by Nihon Keizai Shimbun America, Inc., for the close of October 31, 1988. At year end 1985, the market value of the shares in the Nikkei 500 was 76 percent of the total market value of shares listed in the Tokyo Stock Exchange's First Section.

b. These subgroup indexes are included in a group index with the same number reported elsewhere in this column, and their weights are not included separately in the total to avoid double counting.

c. Communications and transportation.

these groups in the overall indexes at various dates. Because industry averages for the FT-Actuaries World Indices used elsewhere in this paper could not be obtained, we used the F.A.Z. 100 and Nikkei 500 indexes.

Some of the differences in weights have to do with industry structure (whether the industry is dominated by small companies or a few large companies listed on the exchanges), regulation (for instance, banks conduct most of the securities business in Germany), or ownership (for instance, the communications [utility] sector is largely in public hands in Germany but accounts for more than 8 percent of the value of Japanese stocks in the Nikkei 500). Even though the weights by industry groups are not particularly close, most industries can be matched reasonably because both Japan and Germany produce few raw materials and far from all their energy, while competing in exports of finished goods.

A sense of the fundamentals at work in each industry may now be derived by examining the movement of the same industries' stock price averages across countries. Three possibilities can generate correlations ranging from negative to positive. Their sign and size depend on whether news in the industry is primarily redistributive between Germany and Japan (major patentable innovations), whether it consists of unconnected special situations (merger announcements), or whether it affects the industry as a whole more or less irrespective of country (a worldwide glut or shortage of steel).

The equation used to infer the dominant pattern for each of the $i = 1, \ldots, 16$ industries identified in table 9 involves two steps. They lead up to regressing (the change in) the German industry index, ΔG_i, on the overall stock index, ΔG, and that part of the change in the corresponding Japanese industry index, ΔJ_i^*, that is not explained by the overall index, ΔJ, or by the industry's trend (constant α) in Japan. The industry-specific information from Japan, derived as the residual ΔJ_i^* of the estimated equation, $\Delta J_i = \alpha + \beta \Delta J$, is therefore infused from the close of the Japanese market into the German market, which is next in line, to see what resonance it has in the same industry in Germany. Weekly data from Friday's close (or the close of the week's last trading day) were used to construct the rates of change in the stock price indexes entering the regression below:

$$\Delta G_i = \alpha + \beta \, \Delta G + \gamma \, \Delta J_i^*. \tag{8}$$

Table 10. Results of Regressing Change in German Industry Average (ΔG_i) on the German Market (ΔG) and on the Residual Change in the Matching Japanese Industry Average (ΔJ_i^*)[a]

		Coefficient[b]		Summary statistic		
	Industry	ΔG	ΔJ_i^*	$\bar{R}^2$	*Number of observations*	*Durbin-Watson*
(3)	Insurance	1.301 (18.81)	0.144 (2.43)	0.81	83	2.69
(7)	Large chemical combines	0.935 (5.90)	−0.725 (2.96)	0.34	83	2.79
(8)	Other chemical producers	0.778 (19.95)	−0.172 (2.03)	0.83	83	1.98
(16)	Air transport	0.733 (7.62)	0.141 (1.70)	0.32	120	2.20

a. The industry groups are identified in table 9; significant results were obtained for 4 of 16 industries. The regressions were run with constants (not shown). Numbers in parentheses are absolute *t*-statistics.

b. Stock price average changes, constructed from end-of-week observations, started from April 10, 1987, except in (16) where they started July 25, 1986, and went through November 11, 1988. The rate of change from October 16 to October 23, 1987, was excluded from all data reported here, although the results were not much affected by eliminating an outlier in this particular configuration except in air transport, where the coefficient on ΔJ_{16}^* fell from 0.163 (1.97) to 0.141 (1.70). Relative stock price levels appear to be more closely guided by fundamentals than absolute stock price levels, causing stocks to fall in a crisis without greatly disturbing the normal behavior of their indexes relative to each other.

The results on fundamentals, once again, were unimpressive. Table 10 shows that knowledge of the Japanese industry average close could have proved significantly predictive for investors in the Frankfurt market for at most a quarter of the 16 industries examined. Industry effects were transmitted positively in the insurance and air transport sectors, perhaps because global financial and fuel price swings make stock price averages in these groups dance together regardless of their base of operation. In the product innovation, license, and patent-driven world of chemicals and pharmaceuticals, negative relations prevailed: good for you is bad for me. Although at least one of the regression coefficients on ΔJ_i is probably exaggerated (−0.725) by coming close to suggesting a zero-sum game that would be indicated by a coefficient of −1, it is interesting to note that the size and significance levels of all of them were barely affected when the *general* index change in Japan, ΔJ, was added to the list of explanatory variables. In addition, the coefficient on ΔJ was small and insignificant, suggesting that, in these four industries at least, there appears to be something industry-specific—that is, fundamental—moving stock prices across countries.

The chief message from this analysis of the German and Japanese data, however, is quite another: globalization of industry effects is very far from explaining the behavior of the national stock data.[27] One reason for this finding could be that equation 8 leaves out exchange rate changes that could account for poor correlations between industry stock price averages across countries. Assume, for instance, that corporations' major assets consist of a fixed amount of some internationally traded commodity like gold or of a marketable object like an Airbus. The price of stock in any such corporation in any country should always be the same in any one currency, but fluctuate across currencies with their foreign exchange value. Should the U.S. dollar price of gold rise 10 percent while the yen appreciates 10 percent against the dollar, the stock price of the hypothetical corporation, Tokyo Gold, might be unchanged in yen while that of New York Gold rises 10 percent in dollars. The lack of correlation could be accounted for by exchange rate movements if stocks were valued on a liquidation basis alone.

If stocks are valued on the basis of the present value of expected future earnings or dividends, inferring exchange rate effects becomes rather more complicated. Exchange risk exposure on both the revenue and cost sides is continuously managed in the location, purchase, line of business, contract, and hedging decisions of multinational corporations that dominate each national index. All these decisions are forward looking, and expected future exchange rates need not change as much as current spot exchange rates. Under these conditions it is, in general, not clear why even a spontaneous appreciation of the yen, say by 10 percent, should reduce expected future earnings 10 percent in yen, raise the discount rate applied to such earnings 10 percent, or otherwise keep the value of Japanese and U.S. stocks, expressed in a common currency,

27. Using a methodology that also involves the use of residuals (though of either a country or industry index on a world index and not of a national industry index on the corresponding country index), Lessard (1976) found with much earlier data series ending in October 1973 that country factors are two or three times as large as global industry factors in explaining the variance of individual securities. For a test of whether capital moves more easily between industries within a country or between countries within an industry, see also Reitzes and Rousslang (1988).

in line. Indeed, if one allows that the appreciation of the yen may not be spontaneous but the result of growing competitiveness of Japanese products in international markets, it could go hand in hand with Japanese stock prices rising faster than U.S. stocks not only after converting to dollars but even in yen.[28]

In the present instance, where the residual industry-specific stock price movement in Japan is used to help explain the subsequent change in the corresponding industry average in Germany, those exchange rate effects that the Japanese industry shares with the Tokyo stock market as a whole are already implicitly taken into account in deriving the industry-specific residual. Adding the weekly change in the yen-mark exchange rate to the list of explanatory variables in equation 8 should therefore lead to a negative coefficient in the stock-of-gold example, since the valuation of that stock should be unusually sensitive to exchange rate movements.[29] Concretely, an appreciation of the yen, which would be entered as a fall in the yen price of the German mark, should buoy the stock price of Frankfurt Gold, measured in marks, relative to Tokyo Gold, measured in yen.

It turned out that of the 16 industries matched in table 9, exchange rate effects were negative insignificant about twice as often as positive insignificant, with the highest of the absolute t-statistics 1.3. Surprisingly, among the latter group of industries were metal working, large chemical combines, and rubber—all industries that are highly geared to international markets. Having observed also that the coefficients on the industry-specific residuals, ΔJ_i^*, shown in table 10, changed barely at all, we concluded that no reliable insights or appreciable modifications were derived from allowing for bilateral exchange rate change in equation 8. In particular, allowing for such change did not make globalization of industry effects appear any more prevalent between Japan and Germany. Coupling two other markets that close in sequence, the British and American markets, confirms these findings.

INDUSTRY EFFECTS FROM GREAT BRITAIN TO THE UNITED STATES. Just as 99 percent of German industry in the F.A.Z. index could be matched

28. For recent appraisals of exchange rate economics with emphasis on changes in fundamentals, rather than movements toward equilibrium predicted by interest differentials, see Meese and Rogoff (1988); Rose (1988).

29. Weekly exchange rate changes, from Friday noon quotations in London, were constructed from the logarithm of daily exchange rates described in the appendix.

with stock groups for 70 percent of Japanese industry in the Nikkei 500, almost 70 percent of U.S. industry in the Standard & Poor's 500 Composite can be matched with 85 percent of British industry in the FT-Actuaries 500. Table 11 shows the details. Because of a series of privatizations in Great Britain over the past eight years, the industries represented in its overall stock index have gradually become more similar to those in the United States.[30] However, privatization of Britain's electricity industry is not scheduled to begin until 1990, so that only the performance of telephone utilities could be compared across the Atlantic.

Applying the same procedure as before, we first derive that part of the movement in a British industry stock price average, ΔB_i, that is not explained by a constant and the relevant overall average, the FT-500, and that is therefore called the residual industry-specific effect, ΔB_i^*. The question then is whether this residual contributes to the movement in the corresponding industry average in the United States, ΔA_i, when the rate of change in the overall U.S. index, the S&P 500, is also taken into account (ΔA). As for Japan and Germany before, separate national data sources had to be used for the weekly industry averages. They are reported for the close of business Wednesdays in this second pair of countries.

Analogous to equation 8 the estimating equation now is:

$$\Delta A_i = \alpha + \beta\,\Delta A + \gamma\,\Delta B_i^*. \tag{9}$$

Once again, only about a quarter of the industry groups examined, in this case 7 out of 24 (or 6 out of 23 after leaving out the consumer goods composite to avoid double counting), come close to showing statistically significant transference, or shared exposure to industry-specific effects between countries. However, unlike Germany and Japan, changes in industry group averages shared by the United States and Great Britain all go in the same direction and not in the opposite direction as in give-and-take. National indexes for the group "shipping and transportation," which includes air transport, move jointly in both pairs of countries. Otherwise, no significant industry effects were found that all four countries have in common.

Most industry stock price averages that could contain useful infor-

30. For a recent description and analysis of the record of privatization, see Walters (1989).

Table 11. Identification and Weights of Industry and Group Averages in the FT-Actuaries All-Share Index and the S&P 500[a]

	FT class	*British industry group and subsections*	*Weight 12/30/88*	*S&P class*	*U.S. industry group and subsections*	*Weight 12/30/88*
(1)	2	Building materials	3.36	65	Building materials	0.30
(2)	3	Contracting, construction	1.92	180	Homebuilding	0.06
(3)	4	Electricals	0.80	125	Electrical equipment	3.39
(4)	5	Electronics	4.08	87	Computer systems	5.86
(5)	6	Mechanical engineering	3.18	210	Machinery (diversified)	0.84
(6)	8	Metals and metal forming	1.14	225	Metals miscellaneous	0.39
(7)	9	Motors	1.30	15	Automobiles	2.99
(8)	10	Other industrial materials	2.93	10	Aluminum	0.68
(9)	22	Brewers and distillers	4.89	35	Beverages (alcoholic)	0.93
(10)	25	Food manufacturing	4.47	160	Foods	3.25
(11)	26	Food retailing	3.26	163	Food wholesalers	0.24
(12)	27	Health and household products	5.48	. . .	Health care composite	8.16
(13)	29	Leisure	3.28	200	Leisure time	0.18
(14)	31	Packaging and paper	1.02	270	Paper and forest products	2.07
(15)	32	Publishing and printing	2.29	280	Publishing	1.07
(16)	34	Stores	4.79	. . .	Retail stores composite	5.43
(17)	35	Textiles	0.89	350	Textile products	0.10
(18)	42	Chemicals	3.43	70	Chemicals	3.16

(19)[b]	43	Conglomerates	3.19	95	Conglomerates	1.52
(20)	47	Telephone networks	5.40	405	Telephone	5.75
(21)	48	Miscellaneous	3.12	230	Miscellaneous	5.57
(22)	51	Oil and gas	10.76	. . .	Oil composite	10.72
(23)[b]	62	Banks	5.00	410	New York City banks	1.37
(24)[b]	65	Insurance (life)	1.74	420	Life insurance	0.27
(25)[b]	66	Insurance (composite)	2.45	425	Multi-line insurance	1.65
(26)[b]	70	Other financial	1.27	445	Financial-miscellaneous	1.22
		Total matched by industry subsections	85.44	. . .	Total matched by industry subsections	67.17
(27)	1	Capital goods group	18.71	. . .	Capital goods	18.65
(28)	21	Consumer group	30.37	. . .	Consumer goods	33.98
(29)	45	Shipping and transport[c]	2.03	20	Transportation	2.32
	59	500 share index	78.19	400	Industrials	78.62
	61	Financial group	15.70	40	Financial	7.78
	99	All-share index	100.00	500	Composite	100.00

a. FT-Actuaries weightings are published quarterly in the *Financial Times* and S&P 500 weightings monthly in *Stocks in the Standard & Poor's 500: Official Series*. The category "New York City banks" is called "Money Center Banks" in the December 31, 1988, issue of the latter series followed here and now includes First Chicago Bank.

b. The FT-500 and the S&P 500 composite index were used as the measure of "the market." Financial groups were not analyzed because they are not part of the FT-500 and because we did not have weekly data for the All-share index. Conglomerates were also not analyzed for lack of British data, leaving 24 sectors in all.

c. The transportation sector is contained in the "Industrial group" (49, not shown) and hence in the 500 share index (59) in Great Britain but shown separately from the 400 Industrials in the United States.

Table 12. Results for Regressing Change in U.S. Industry Average (ΔA_i) on the U.S. Market (ΔA) and on the Residual Change in the Matching British Industry Average (ΔB_i^*)[a]

		Coefficient		Summary statistic	
	Industry	ΔA	ΔB_i^*	$\bar{R}^2$	Durbin-Watson
(12)	Health care composite	0.988 (21.55)	0.205 (3.87)	0.84	2.00
(13)	Leisure time	1.332 (12.89)	0.435 (1.96)	0.52	2.34
(14)	Paper and forest products	1.225 (22.43)	0.158 (1.90)	0.77	1.88
(20)	Telephone utilities	0.855 (15.96)	0.133 (2.17)	0.63	1.64
(22)	Oil composite	0.743 (14.95)	0.546 (9.27)	0.69	2.09
(28)	Consumer goods composite	1.085 (29.18)	0.293 (1.95)	0.85	2.45
(29)	Shipping and transportation	1.082 (23.75)	0.189 (2.12)	0.79	2.06

a. Industry groups and subsections are identified in table 11; including the composites, significant results were obtained for at most 7 out of 24 industries. The regressions were run with constant (not shown). There were 151 weekly (Wednesday to Wednesday close) rates of change from the week ending January 15, 1986, to December 9, 1988. The change during the week ending October 21, 1987, was excluded. Numbers in parentheses are absolute t-statistics.

mation for their counterparts in the United States over and above what the broad averages can provide have coefficients in table 12 that seem rather unimpressive. The oil composite is the only major exception. That industry is international in operations and exposure and tends to have a low beta coefficient in major industrial countries. It would be surprising indeed if even specific movements in this industry did not have an element in common with the succeeding market.

Otherwise, once again, very little was found. Adding weekly changes in the sterling price of the dollar to the list of explanatory variables in equation 9 yielded 11 negative insignificant and 11 positive insignificant coefficients. Furthermore, at least one of the two negative significant effects, found for electricals (industry 3) and stores (industry 16), may have to be attributed to the luck of the draw since it is hard to see why an appreciating pound should be much good for May Department Stores, a component of the S&P 500, in the United States.

Conclusions

Since early 1986, major national equity markets have been deregulated and integrated with each other at a pace reminiscent of the development of the market for Eurocurrency debt issues about a dozen years earlier.[31] The stock market crash of October 1987 appears to have contributed to internationalization yet further, though in another way. The spectacle of nearly simultaneous price collapses around the world in the crash should have led investors to revise their views about how much diversification gain could really be reaped from investing in different national stock markets. Since that time, correlations among the indexes of these markets have been higher. As a sign of increased interdependence after the crash, after-hours price movements in U.S. stocks with listings in Tokyo and London have been reflected closely in opening New York prices.[32] If one refers to "market" effects on individual stocks, one may increasingly mean the world market that is active in different locations around the clock.

Equity markets may have grown closer together and events may have acquired more common global significance, but much macroeconomic news should still move national stock price averages in different directions. Unfortunately, theory does not predict unequivocally how stock prices should move relative to other asset prices. Our empirical findings on variables such as exchange rates and the prices of oil and gold were predominantly negative. Few significant effects on daily stock price changes could be found.

Next we searched for effects that we think of as arising from fundamentals on the supply side of stock valuation. Buying stocks is like buying a ticket to the fortunes of a particular firm and its earnings, which in turn are correlated with the prospects of the industry in which it conducts its principal operations. Hence, this "supply side" of the stock market—the side that emphasizes what earnings profiles and contingencies come with each stock—will be much more differentiated by industry than the demand side, which is governed by general portfolio manage-

31. For further details, see International Monetary Fund (1988); Watson and others (1988, pp. 35–49). For recent changes in stock market regulation and taxation in the four major countries, see also Stonham (1987, p. 96); Suzuki (1987, p. 102); Lipschitz and others (1989, p. 48).

32. See Neumark, Tinsley, and Tosini (1988).

ment considerations.[33] In other words, although few supply-side events would affect nearly all industries the same way, many demand-side events, such as a rise in the discount rate, could.

In our empirical investigation, however, industry effects across countries were generally not significant. It is an old story that, in accounting for variations of individual stock prices in national markets, the market factor is at least twice as strong as the industry factor.[34] All such results are conditional upon the frequency with which stock price quotations are observed: industry effects may well gain on market effects the lower the frequency, and hence the greater time-averaging, of observations. Daily changes in individual stock prices, however, are not dominated by industry-specific effects but by whatever moves the market as a whole.

Messages between the four major stock markets thus tend to be relayed not primarily at the level of the common industry components of their stock price averages but at the level of the aggregate national stock indexes. The implication is that stock prices are swayed mostly by changing views on the prospects of stocks in general relative to other financial and real assets—by changes in the demand for stocks or the discount rate applied to future dividends—and not by changes in views about the quality of the underlying assets or future earnings that one would expect to be more industry specific.

Because large institutional investors now hold portfolios that are diversified internationally in the major industrial countries, whether stocks are of foreign or domestic issue is no longer of overriding importance to many of them. Changes in demand appear to dominate stock price movements. Today, changes in demand for equities must be global to be effective. Past patterns of dominance exercised by particular national stock markets are likely to become less distinct as the same set of actors, equipped with more and more of the same information, is increasingly present in every major market and able to take advantage of its trading hours as opportunity dictates.[35] Even over the three years

33. Demand- and supply-side views of the stock market are fully characterized in Shiller (1984, pp. 28–37).

34. See, for instance, the summary in Brealey (1983, p. 117).

35. A caution is in order here. In the absence of barriers, or potential barriers, of the kind that would justify country risk and exchange rate premiums, an integrated North-Atlantic-Pacific capital market would imply similar interest rates or expected yields for

dealt with in this study, an increase in international sensitivity of national markets has become evident.

We prefer to attribute this increase to the development of a *global* random walk in efficient markets, with responses to news appearing sequentially in individual markets because they do not operate and close at the same time. Because of the difficulty in pointing to external news to explain market movements, however, we cannot rule out the possibility that their correlation reflects simply contagious market shocks unrelated to fundamentals.

Whatever the reason, at least two other studies have detected signs in the precrash data for the 1980s that world stock prices in different countries have been tending to move more similarly in the 1980s than before.[36] The first of these goes on to recommend increased international regulatory coordination to augment the effectiveness of domestic measures in lessening the chances of another market collapse if the trend toward globalization continues. International stock price linkages may have been largely unobserved and indirect up through the crash to the extent domestic investors still shaped the decline in each of the largest markets during critical days in October 1987.[37] Since then, however, such links have become increasingly direct. We believe that they will grow tighter in coming years even though market volatility subsided during 1988, at least temporarily. On the other hand, we would not place it in the power or province of governments to interdict a global stock market collapse any more than they can either recognize or prevent stock market bubbles. But we do agree that increased regulatory coordination may be necessary to prevent any such low-probability event from impairing the payment, clearing, and settlements systems of the leading countries and thus disrupt real economic activity worldwide.

Although we hesitate to use the behavior of the major stock markets to reflect on the state of the world economy, two last points come to

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financial claims of similar risk and liquidity without any other regard to nationality or location. However, increased correlations between sequential daily movements in national stock price indexes should not, by themselves, be taken to imply that fundamental valuations are being equalized across borders or are being kept equal. See Dwyer and Hafer (1988). Furthermore, if correlations between the changes in two national averages would rise together with volatility in each, these averages could be expected to move, over time, just as far apart as before.

36. See Bennett and Kelleher (1988, p. 26); Friedman and Weiller (1987).

37. This is maintained by Aderhold, Cumming, and Harwood (1988).

mind in attempting to relate the results of this study to the macrotheoretic work of others. First, if one can interpret the lack of industry stock price correlations to represent a lack of important supply shocks to the economy, that suggests that aggregate demand is the principal source of economic instability generally.[38] And, second, if imperfect information that leads to equity and credit rationing creates national and international financial linkages that amplify disturbances, then small disturbances that initially cause only a slight change—say, in lenders' and investors' uncertainty about the future prospects of their commitments—can have large, worldwide effects eventually.[39] If big effects do indeed follow from small, quite possibly invisible, causes, then amplification through "contagion" may be consistent with the ongoing propagation of fundamentals.

APPENDIX

THIS APPENDIX identifies the daily variables used in the paper.

S_k: The logarithm of the daily level (based on middle market prices at the close of business) of national stock price indexes. These indexes are taken from the *FT-Actuaries World Indices,* which are jointly compiled by the Financial Times Limited, Goldman, Sachs & Co., and County NatWest/Wood Mackenzie in conjunction with the Institute of Actuaries and the Faculty of Actuaries. Subscript k may refer to the United States (a), Great Britain (b), Germany (g), or Japan (j), or to denomination in their currency.

38. The latter has been found by Blanchard and Quah (1988). For a rather different inference from U.S. data, see Campbell and Mankiw (1987).

39. For the systematic exposition, see Stiglitz (1988); Bernanke and Gertler (1989). Cutler, Poterba, and Summers (1988) have also recommended exploring propagation mechanisms that could cause relatively small shocks to have large effects on market prices. However, the route they have suggested, informational freeloading and positive feedback from observed asset prices, could be viewed as the antithesis of efficient markets. As Brock (1990) has explained, if positive feedback exists, it could either lead to deterministic chaos whose profit opportunities would be detected and thereby removed by efficient investors, or it could lead to a clash with efficient markets that those who provide positive feedback would be expected to lose. The question then becomes how positive feedback, which can easily turn small causes to large effects through its internal dynamics, can persist in the face of such prospects.

e_{ka}: The exchange rate expressed as the logarithm of daily London noon spot quotations in currency k units per U.S. dollar.

Δe_{ks}: Multilateral (s) exchange rate change constructed as: $0.40\ \Delta e_{ka} + 0.13\ \Delta e_{kb} + 0.26\ \Delta e_{kg} + 0.21\ \Delta e_{kj}$, $k = a, b, g$, or j, $\Delta e_{kk} = 0$, where the weights are the 1987 average normalized shares of the four currencies above in the SDR.

i_k: For $k = a, b, g$, or j: offered rate on three-month Eurocurrency deposits denominated in currency k. The data are mid-morning (10:30 A.M.) quotations at annual rates in the London market, except for sterling quotations, which are from the Paris market. For $k = s$: the three-month weighted average rate, i_s, constructed as the sum $0.40i_a + 0.13i_b + 0.26i_g + 0.21i_j$.

pg: Gold price per fine ounce in U.S. dollars expressed as the logarithm of the afternoon (15:00) fixing in London.

po: Price per barrel of crude oil expressed as the logarithm of the *next* (1,000 barrel) futures contract (the one closest to delivery or final settlement) for what is traded as "light sweet West Texas Intermediate" on the New York Mercantile Exchange. The price used is that determined at the 9:45 A.M. (14:45 London time) open of crude on that exchange.

Comments and Discussion

N. Gregory Mankiw: This is a timely paper. Over the past few years the interactions among the world's stock markets have received much attention from economists and the news media. In an attempt to document and understand these interactions, George von Furstenberg and Bang Nam Jeon look at daily data on stock prices from four major world stock markets and compare fluctuations before and after the crash of October 1987.

The strength of this paper lies in its presentation of simple and revealing descriptions of these data. The first part of the paper, the so-called technical analysis, examines how closely different countries' stock markets move together. What emerges is a robust finding that the correlations among the world's stock markets increased substantially after October 1987. Comparing the year before the crash with the year after the crash, the authors report that the typical correlation rose from about 0.2 to about 0.4. To me, this is the most intriguing result in the paper.

The second part of the paper, the so-called fundamental analysis, tries to relate stock price movements to other frequently measured economic variables, such as interest rates, exchange rates, oil prices, and so on. Here the authors discover much less. Like many others before them, they find that relating the stock market to news about fundamentals is hard to do; instead, stock prices appear to have a life of their own. Anyone who has listened to the feeble attempts by the nightly news to explain the day's stock market would probably have anticipated this conclusion.

The weakness of this paper lies in its failure to tell us clearly what the underlying questions are. In other words, the authors don't tell us how we should think about the world differently after seeing their results.

Should we be less concerned about stock price movements because the authors cannot relate them to fundamentals? Should we weaken our faith in the efficient markets hypothesis? Should the increased correlation among the world's stock markets strengthen our commitment to international policy coordination? In short, the authors show us the "links," but they are less clear on the "messages."

One question that the authors' evidence might help answer is why the stock market crashed in October 1987. Presumably this is one motivation for splitting the sample before and after October 1987, as they have done. Yet the authors say little about the crash, even though they report systematic differences between the year before and the year after.

To see what the findings in this paper might tell us about the crash, let us entertain the following model. Suppose there are many countries, each with a stock market that is subject to worldwide shocks and country-specific shocks. Suppose further that the traditional mean-variance capital asset pricing model applies to the world economy, so that the required rate of return for a country's market is determined by its covariance with the world return. That is,

$$\text{(1)} \qquad \mathrm{E}R = A\,\mathrm{Cov}(R,R_W),$$

where R is the excess return in any given market, R_W is the world excess return (the average of all the R's), and A is the Arrow-Pratt coefficient of relative risk aversion. Assuming that the many countries are symmetric with respect to each other, it is straightforward to show that the required rate of return can be written as

$$\text{(2)} \qquad \mathrm{E}R = A\,\rho\,\mathrm{Var}(R),$$

where ρ is the correlation between any two countries' returns. Writing the expected return in this way allows me to use some of the summary statistics that this paper reports.

As in almost any asset pricing model, the required rate of return in this model depends on volatility. An increase in volatility increases the required rate of return, which in turn depresses stock prices. We can see from the paper's table 1, however, that any explanation of the October crash based on increased volatility will likely be unsuccessful, because volatility rose only slightly in the year after the crash, and even fell slightly in Japan.

A more promising explanation for the crash might come from the other factor in equation 2, the correlation between different stock markets. An increase in this correlation implies that less of a country's risk is diversifiable internationally. The results in this paper, such as those in table 8, show that this correlation more than doubled. If this sort of international CAPM describes returns, then the required rate of return should have more than doubled in October as well.

Whether a doubling in the required rate of return can account for a crash of the size we observed depends on how long market participants expected the increase to last. If the required rate of return rose, say, from 5 percent to 10 percent, and if the change were perceived to last only one year, then it would explain only a 5 percent fall in the market. Yet if the increase in the international correlations was expected to last a few years, then the implied increase in the required return could easily account for a 20 percent fall in equity values.

The question that this story leaves open, as do von Furstenberg and Jeon, is why the correlations among stock markets increased so dramatically in October 1987. Either news has become more international in nature, or animal spirits have. I know of no good reason to expect either. But there must be some reason, for it seems hard to argue with the increase in the correlations that this paper documents.

There are many directions that this sort of research can take from here. One would be to try to pin down more precisely when these stock markets became more interconnected. One could apply Goldfeld-Quandt switching regression techniques to see if the apparent change in regime actually occurred in October 1987, as these authors assume. One could also look into whether the regime change occurred gradually or rapidly and whether it coincided with the declines in stock prices.

Another direction for research would be to extend the sample period back further to examine whether the change observed in October 1987 has precedents. If we found that the recent increase in international stock market correlations reflects a longer-term trend, we would learn that the world's economies are more connected today than they have been in the past. This finding itself would be significant, as it would suggest an increased instability in the world economy.

I suspect it is more likely, however, that these international stock market correlations fluctuate substantially over time and that the increase documented in this paper is just one instance of these fluctuations. If this suspicion is right, it would be useful to study how these correlations vary. For example, are the fluctuations in these correlations transitory or persistent? The more persistent they are, the greater impact they should have on market values. In addition, one could examine whether these correlations fluctuate inversely with the level of stock prices, as the international CAPM suggests they should and as they apparently did in the single instance of October 1987.

To sum up, I learned from this paper that the forces driving the world's stock markets appear to have changed around the time of the October 1987 crash, that the world markets seem more interconnected now than they did before. But until more work is done, I am not sure what to make of this observation.

Robert J. Shiller: The stock market crash of October 1987 was the most dramatic single event in world financial history. Its effects should be a worthwhile topic for research. In the absence of an agreed-upon theoretical framework to guide the research, however, quantitative research tends to work out to be purely descriptive.

George von Furstenberg and Bang Nam Jeon mount a sincere effort to provide both the description of the facts—the changes in markets around the world that followed the crash—and the theoretical framework to understand them. I think that they were quite successful in the former, but as unsuccessful as everyone else has been in the latter.

In interpreting the empirical results presented in their paper, it is important to keep in mind the overlap in the differencing intervals of the various countries. The data that the authors use are daily log price changes—the log price change of a stock index between the day's close and the preceding day's close, 24 hours earlier. The closing times for the four markets are given in their table 2: in Greenwich mean time, 6:00 A.M. Tokyo, 12:30 P.M. Frankfurt, 5:00 P.M. London, and 9:00 P.M. New York. We can learn something about the expected coefficients in their price-change model (equations 3 through 6) by noting the extent of the implied overlap. The fraction of a day overlapped between the Tokyo price change and the New York price change of the preceding day is 0.625, between Frankfurt and Tokyo on the same day is 0.729, between London and Frankfurt is 0.813, and between New York and London is 0.833.

The theoretical slope coefficient in a regression of the log price change in country i on the log price change of country j whose market closed last before that of country i would be the overlap proportions given above if all log stock prices were the same internationally and a random walk. But, of course, stock prices are not the same in all countries. Suppose the ith country's log stock price index at time t is given by $P_{it} = \omega_i W_t + \sigma_i u_{it}$ where W_t is a world factor (a unit Wiener process, that is, a continuous-time random walk for which the standard deviation of the daily change is 1.000), u_{it} is a country-specific factor (also a unit Wiener process), and the constants ω_i and σ_i reflect the importance given the two factors in country i. Then the regression coefficient for countries i and j would be $b_{ij} = \Omega_{ij}\omega_i\omega_j/(\omega_j^2 + \sigma_j^2)$ where Ω_{ij} is the extent of overlap between those two markets. Thus, for example, if the world component had the same impact on all markets and the country-specific component of log stock prices were of the same importance as the world component, we would then expect the coefficient of the lagged price to be one-half the proportion of overlap. The error term in the regression is, as the authors assert, a first-order moving average process. The covariance between the error term and the lagged error term is $-(1-\Omega_{ij})\ b_{ij}\omega_i\omega_j$, which is always negative.

From the viewpoint of this random walk model, coefficients such as those on lagged log price changes are consistent, given the extent of the overlap in the data, with a situation in which the world component accounted for substantially less than half the variation in stock price changes before the crash but accounted for roughly half afterward. I would interpret the change in impulse response functions presented in table 6 and the changes in cross-correlations of weekly log price changes shown in table 8 as reflecting the same phenomenon.

The authors sketch out how a structural model might relate fundamentals to stock prices across countries. They specifically observe that some shocks would have different relative effects than others. For example, effects of oil price shocks would be different because of different dependencies on oil. By this interpretation, they seem to be saying that the change in responsiveness of individual country stocks might be due to something like a change in the amount of news generated worldwide about the price of oil. In any case, the authors report that they could get no significant results using fundamentals and note that past efforts to provide good explanatory equations for stock prices using nonspeculative price data have also been unsuccessful. Indeed, I would say that it is even worse than that: not only can we not explain speculative prices, but also speculative prices get excited at times when all else is calm. As William Schwert concluded from a careful study of patterns of changing stock market volatility, speculative prices tend to go in and out of periods of high volatility, and these high-volatility periods tend not to correspond to high-volatility periods for nonspeculative price variables.[1]

Probably the reason we cannot explain stock price index movements in terms of such fundamentals is that stock price indexes are not so determined. Most stock price index movements seem to be due to social attitude changes, spontaneous changes of public opinion. Why, after all, did the Dow drop 15 percent in the two and a half hours between 1:30 and 4:00 on the afternoon of October 19, 1987? The interval is so short that the list of news stories that could have caused the drop is necessarily short. Indeed, the only substantial news arising during that period was the news of the price drop itself. If the market is to be described as responding quickly to news, then it is news that the market generated itself.

People appear to react to price drops because they think that the drops are evidence on market psychology. On a survey of investors that I conducted just after the crash, most said that they thought at the time of the crash that the crash was due to investor psychology, rather than to fundamentals.[2] Thus, the representative investor does not have a model of the stock market that even remotely resembles that sketched out by the authors.

There is evidence that the time of the crash was a time of important changes in the perceived outlook for future speculative prices. Richard Hoey, David Rolley, and Helen Hotchkiss at Drexel Burnham Lambert have conducted regular surveys of institutional investment managers. Their survey of over 300 such managers shows a sudden and precipitous drop, at the time of the crash, in the proportion who thought that "three months from today, the market will be in a bull market." In September 1987 the proportion who agreed with this statement was 47.9 percent; in November it was 19.9 percent.[3] Since a bull market is a rising market, this means that the price change at the time of the crash was associated with changes in expected future price changes.

1. Schwert (1987).
2. Shiller (1989b).
3. Hoey, Rolley, and Hotchkiss (1988).

The meager evidence we have on changes in expectations for long-run fundamentals does not suggest that the stock market crash could be ascribed to changes in these. The Hoey, Rolley, and Hotchkiss survey showed virtually no change in the long-term rate of discount. Between September 1987 and November 1987 the expected 10-year real pretax bond yield fell from 4.00 percent to 3.71 percent, which would suggest a modest rise, rather than a precipitous fall, in stock prices. Neither is there any substantial change in the expected growth of earnings at the time of the crash. Jeremy J. Siegel has pointed out that the changes around the time of the crash were more in the dispersion of forecasts than in the average level of forecasts.[4] The Blue Chip Economic Indicators show virtually no change in expected pretax profits growth. In their survey of 51 professional forecasters in the first three working days of October 1987, immediately before the crash, pretax profits (current dollars) were expected to grow 7.1 percent during the five years 1988–92 and 7.3 percent during 1993–97. In their first postcrash long-range projection survey, conducted the first three days of March 1988, pretax profits were expected to grow 7.0 percent during 1990–94 and 7.5 percent during 1995–99. (In the March 1988 survey, pretax profits were expected to grow 2.9 percent in 1988 and 5.9 percent in 1989.) By this evidence there appears to be no more than a modest decline in the expected long-run outlook for corporate profits before and after the crash, and so, if their sample is representative of investor expectations, the causes of the crash would not seem ascribable to fundamentals.[5]

If the crash itself is to be explained in terms of investors' changing perceptions of each other's behavior, then we might plausibly explain in these same terms the changes wrought by the crash in the international correlation of price changes. The increase in the international component in stock prices after the crash may be due to nothing more than the idea among investors that, after a stock market crash that affected all the major markets of the world, other investors are looking more at foreign price movements. As long as investors feel that other investors are doing so, it may become approximately rational to do so also.

Indeed, judging from my analysis of London and New York data, the international correlation of stock price movements cannot be justified

4. Siegel (1988).

5. Data are courtesy of Blue Chip Indicators, Eggert Economic Enterprises, Inc., Sedona, Arizona.

by either correlation of fundamentals across countries or pooling of information about such fundamentals.[6] Thus the most promising way to interpret these correlations is in terms of market psychology or popular models.

General Discussion

Peter Kenen suggested that some alternative disaggregations of stock markets might be more useful than the disaggregation by industry reported on in the paper. A promising approach would classify stocks into those that are traded on several markets, those that are not traded abroad but operate multinationally, and those that trade and operate locally. This kind of classification might sharpen the relation of stock prices to shocks and reveal the extent to which international stock price correlations are a by-product of correlations in goods markets.

Christopher Sims pointed out that even though the authors had in mind an unobservable components model with both market-specific and worldwide shocks, their statistical work did not apply such a model. He particularly argued for including dynamics linking fundamentals and stock prices and expected that the two would be related mostly at low frequencies. Without allowing for dynamics, the authors are restricted to correlations of the changes in prices and fundamentals that capture only high-frequency movements. Sims also conjectured that the major news associated with the stock market crash may have been the eventual gain of credibility as an inflation-fighter by Alan Greenspan.

Steven Durlauf suggested that it might be more instructive to study the volatility of stock markets and how this volatility is passed on from one market to another rather than changes in the level of stock prices. He also reasoned that changes in variables such as exchange rates or interest rates cannot be interpreted as changes in fundamentals at the high frequencies represented by daily price changes. Therefore the lack of correspondence between changes in those variables and stock prices is not surprising. Further, in the absence of a fundamentals explanation of movements within stock markets, we cannot draw inferences about fundamentals fluctuations across markets.

6. Shiller (1989a).

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