by Richard Roll

The International Crash of October 1987

All major world markets declined substantially in October 1987—an exceptional occurrence, given the usual modest correlations of returns across countries. Of 23 markets, 19 declined more than 20 per cent. The U. S. market had the fifth smallest decline in local-currency units, but came in only 11th out of 23 when returns are restated in a common currency.

The U.S. market was not the first to decline sharply. Non-Japanese Asian markets began a severe decline on October 19 (their time). This decline was echoed first by a number of European markets, then by North America and, finally, by Japan. Most of these same markets, however, had experienced significant but less severe declines in the latter part of the previous week. With the exception of the U.S. and Canada, markets continued downward through the end of October, and some of the declines were as large as the great crash on October 19.

Various institutional characteristics have been blamed as contributors to the crash. Univariate regressions indicate that the presence of an official specialist, computer-directed trading, price limits and margin requirements were associated with less severe stock market declines in October 1987, while continuous auctions and automated quotations were associated with larger declines. In multiple regressions, however, several of these variables, including price limits and margin requirements, were found to be insignificant.

October's crash could be ascribed to the normal response of each country's stock market to a worldwide market movement. A world market index was found to be statistically related to monthly returns in every country during the period from the beginning of 1981 up until the month before the crash. The magnitude of market response differed materially across countries. The response coefficient, or beta, was by far the most statistically significant explanatory variable in the October crash, swamping the influences of the institutional market characteristics. Only one institutional variable—continuous auctions—had even a marginally significant influence on the estimated beta.

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THE SHARP DROP in U.S. stock prices in October 1987 gave birth to at least one industry—the production of explanations for the crash. Among the most popular are those related to the U.S. market's institutional structure and practices—computer-assisted trading, portfolio insurance, the organized exchange specialists, concurrent trading in stock index futures, margin rules, and the absence of

Footnotes appear at end of article.

Table I Stock Price Index Percentage Changes in Major Markets (calendar year 1987 and October 1987)[a]

	Local Currency Units		U.S. Dollars	
	1987	*October*	*1987*	*October*
Australia[b]	−3.6	−41.8	4.7	−44.9
Austria	−17.6	−11.4	0.7	−5.8
Belgium	−15.5	−23.2	3.1	−18.9
Canada[b]	4.0	−22.5	10.4	−22.9
Denmark	−4.5	−12.5	15.5	−7.3
France	−27.8	−22.9	−13.9	−19.5
Germany	−36.8	−22.3	−22.7	−17.1
Hong Kong	−11.3	−45.8	−11.0	−45.8
Ireland	−12.3	−29.1	4.7	−25.4
Italy	−32.4	−16.3	−22.3	−12.9
Japan	8.5	−12.8	41.4	−7.7
Malaysia	6.9	−39.8	11.7	−39.3
Mexico[b,c]	158.9	−35.0	5.5	−37.6
Netherlands	−18.9	−23.3	0.3	−18.1
New Zealand[b]	−38.7	−29.3	−23.8	−36.0
Norway	−14.0	−30.5	1.7	−28.8
Singapore	−10.6	−42.2	−2.7	−41.6
South Africa[b]	−8.8	−23.9	33.5	−29.0
Spain	8.2	−27.7	32.6	−23.1
Sweden	−15.1	−21.8	−0.9	−18.6
Switzerland	−34.0	−26.1	−16.5	−20.8
United Kingdom	4.6	−26.4	32.5	−22.1
United States	0.5	−21.6	0.5	−21.6

a. Annual average dividend yields are generally in the 2 to 5 per cent range except for Japan and Mexico, which have average dividend yields less than 1 per cent.
b. The currencies of these countries depreciated against the dollar during October 1987.
c. Mexico is the only country whose currency did *not* appreciate against the dollar during 1987.

"circuit breakers" such as trading suspensions and limitations on price movements. Several commission reports about the crash focus on these institutional arrangements.

As regulatory agencies and potential regulatees debate the most appropriate means for preventing another crash, the focus again is on institutional form. The debaters seem to accept without question that the arrangements in place during October were somehow related to the event. Yet there is virtually no evidence to support such a view. If institutional structure of the U.S. market had been the sole culprit, the market would have crashed even earlier. There must have been an underlying "trigger." Some have pointed to the U.S. trade deficit, to anticipations about the 1988 elections, to fears of a recession. But no one has been able to substantiate the underlying cause of the October market decline.

The likely impact of both market structure and macroeconomic conditions can perhaps be deduced by comparing circumstances in the United States with circumstances prevailing in other markets around the world. Indeed, we are blessed with a natural laboratory experiment, for conditions varied widely across countries. To the extent that institutions and economics influence the stock market, we should be able to detect those influences by comparing behaviors in various markets during October 1987.

Table II Correlation Coefficients of Monthly Percentage Changes in Major Stock Market Indexes (local currencies, June 1981–September 1987)

	Australia	*Austria*	*Belgium*	*Canada*	*Denmark*	*France*	*Germany*	*Hong Kong*	*Ireland*	*Italy*
Austria	0.219									
Belgium	0.190	0.222								
Canada	0.568	0.250	0.215							
Denmark	0.217	−0.062	0.219	0.301						
France	0.180	0.263	0.355	0.351	0.241					
Germany	0.145	0.406	0.315	0.194	0.215	0.327				
Hong Kong	0.321	0.174	0.129	0.236	0.120	0.201	0.304			
Ireland	0.349	0.202	0.361	0.490	0.387	0.374	0.067	0.320		
Italy	0.209	0.224	0.307	0.321	0.150	0.459	0.257	0.216	0.275	
Japan	0.182	−0.025	0.223	0.294	0.186	0.361	0.147	0.137	0.183	0.241
Malaysia	0.329	−0.013	0.096	0.274	0.151	−0.134	−0.020	0.159	0.082	−0.119
Mexico	0.220	0.018	0.104	0.114	−0.174	−0.009	0.002	0.149	0.113	0.114
Netherlands	0.294	0.232	0.344	0.545	0.341	0.344	0.511	0.395	0.373	0.344
New Zealand	0.389	0.290	0.275	0.230	0.148	0.247	0.318	0.352	0.314	0.142
Norway	0.355	0.009	0.233	0.381	0.324	0.231	0.173	0.356	0.306	0.042
Singapore	0.374	0.030	0.133	0.320	0.133	−0.085	0.037	0.219	0.102	−0.038
South Africa	0.279	0.159	0.143	0.385	−0.113	0.267	0.007	−0.095	0.024	0.093
Spain	0.147	0.018	0.050	0.190	0.019	0.255	0.147	0.193	0.175	0.290
Sweden	0.327	0.161	0.158	0.376	0.131	0.159	0.227	0.196	0.122	0.330
Switzerland	0.334	0.401	0.276	0.551	0.283	0.307	0.675	0.379	0.290	0.287
United Kingdom	0.377	0.073	0.381	0.590	0.218	0.332	0.263	0.431	0.467	0.328
United States	0.328	0.138	0.250	0.720	0.351	0.390	0.209	0.114	0.380	0.224

Movements Around the Crash

During the month of October, the declines experienced in all markets were concentrated in the second half of the month. Figures A through F present the day-to-day closing index numbers for each market over the entire month of October, restated to 1.0 currency units on October 1. Figure G plots equal-weighted regional indexes over a shorter period around the crash, beginning on October 14 and ending on October 26. Figure H gives a similar portrait of the six largest individual markets. All eight graphs are plotted in actual world time; the tick marks reflect each index's value at the daily New York market close—4:00 p.m. U.S. Eastern Standard Time.[4] The graphs are on the same vertical scale and plotted for the same world time, so they can easily be compared.

The earliest significant declines occurred on October 14 (in the North American markets and in France, The Netherlands and Spain). Most world markets experienced at least some decline for the week ending October 16. In the U.S. market, by far the largest daily decline occurred on October 19. However, many European markets split their declines between their 19th (preceding the U.S. decline) and their 20th. In the cases of Belgium, France, Germany, The Netherlands, Sweden and Switzerland, the biggest down day was their 19th.

In the Asian markets, Hong Kong, Malaysia and Singapore had major declines on both their 19th and 20th, the movement on their 19th preceding the U.S. decline by more than 12 hours. (These markets close before the North American markets open.) Japan fell only slightly on its 19th, but it joined Australia and New Zealand for a major drop on the 20th (i.e., late in the day on October 19 in the U.S.), lagging the major U.S. decline by several hours.

On a given calendar day, the North American markets are the last to trade. Most of the other markets around the world displayed dramatic declines on their October 19—foreshadowing the crash in North America. With just a few exceptions, the most important being Japan, other countries experienced most of their declines either prior to the opening of the U.S. market on the 19th or approximately straddling the U.S. market's October 19 session (i.e., on October 19 and 20, local time).

This seems to be some evidence against the widely expressed view that the U.S. market pulled down all the other world markets on October 19. However, it is true that the U.S. experienced one of the largest declines in the previous week (see Figure H). So there remains the possibility that other market crashes, though generally occurring before the major U.S. crash, were in fact precipitated by the relatively modest U.S. decline from October 14 through 16.[5]

Following the crash, there was a one-day advance in most markets (including the U.S.) on the 21st. Figure G shows that this advance began first in the Asian and Pacific markets, then spread to Europe and finally to North America. Many markets resumed a substantial decline after October 21, however. From the 22nd through the end of October, every market except the U.S. fell, and every decline except that of Canada was substantial (in local-currency units).[6] Some of these cases were at least partial holdovers from market closures on the 19th (e.g., Hong Kong) or drawn out by successive encounters of exchange price limits. In Europe and Asia, however, the weekend from the 23rd to the 25th was just as bad, and in a few cases worse, than the great crash weekend of October 16 to 19. (See Figures C, D and E or Figure G.)

The overall pattern of intertemporal price movements in the various markets suggests the presence of some underlying fundamental factor, but it debunks the notion that an institutional defect in the U.S. market was the cause. It also seems inconsistent with a U.S.-specific macroeconomic event. If anything, the U.S. market lagged the initial price movements that began in earnest on October 14, and it also did not participate in further declines that occurred during the last weekend in October. This would not be the observed empirical pattern if, for instance, portfolio insurance and program trading in New York and Chicago were the basic triggers of the worldwide crash.

October 1987—Before and After

The strong market decline during October 1987 followed what for many countries had been an unprecedented market increase during the first nine months of the year. In the U.S. market, for instance, stock prices advanced 31.4 per cent over those nine months. Some commentators have suggested that the real cause of October's decline was overinflated prices generated by a speculative bubble during the earlier period. Of the 23 countries in our sample, 20 experienced

Figure A October 1987 Stock Prices—North America

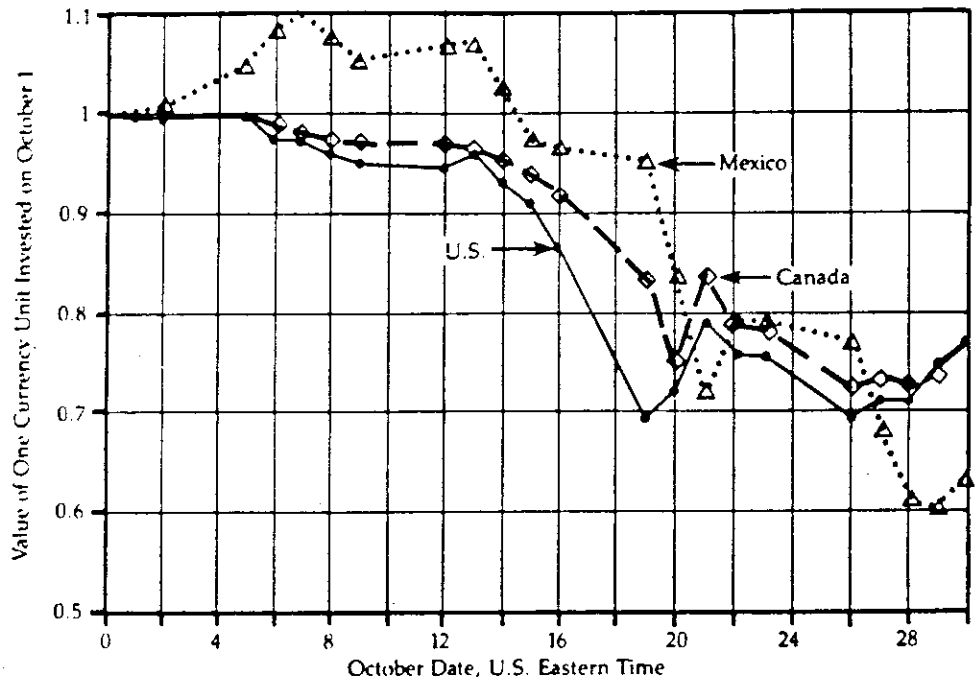


Figure B October 1987 Stock Prices—Ireland, South Africa, U.K.

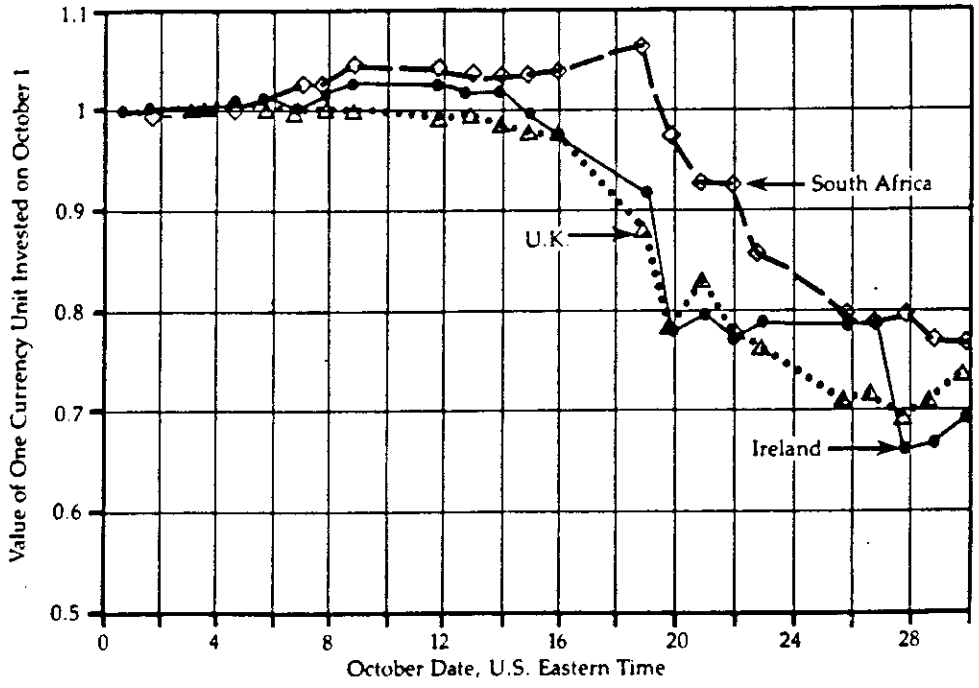


Figure C October 1987 Stock Prices—Larger European Countries

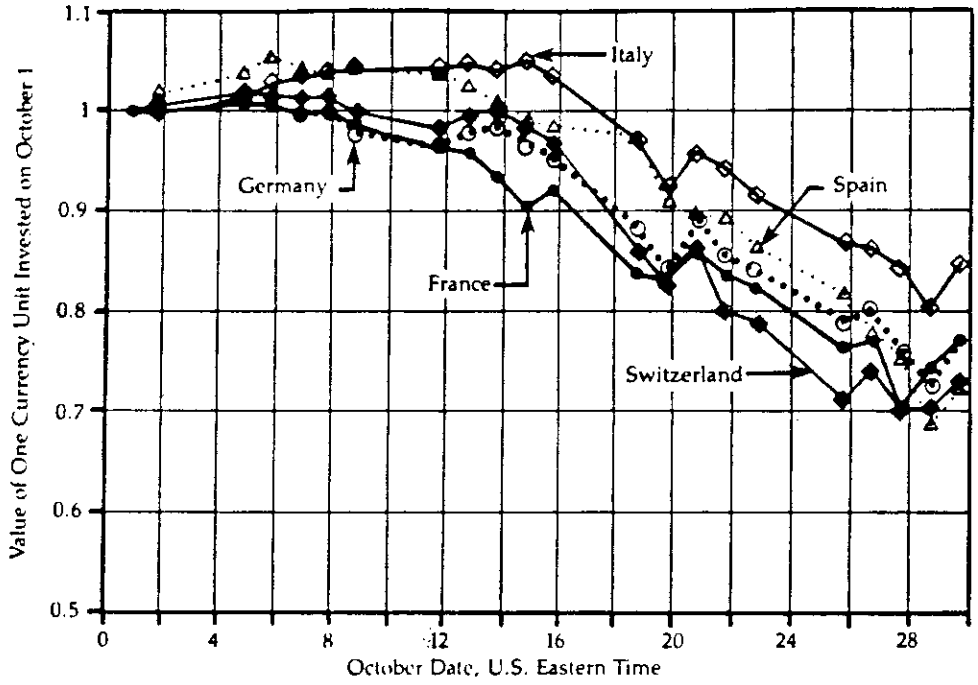


Figure D October 1987 Stock Prices—Smaller European Countries

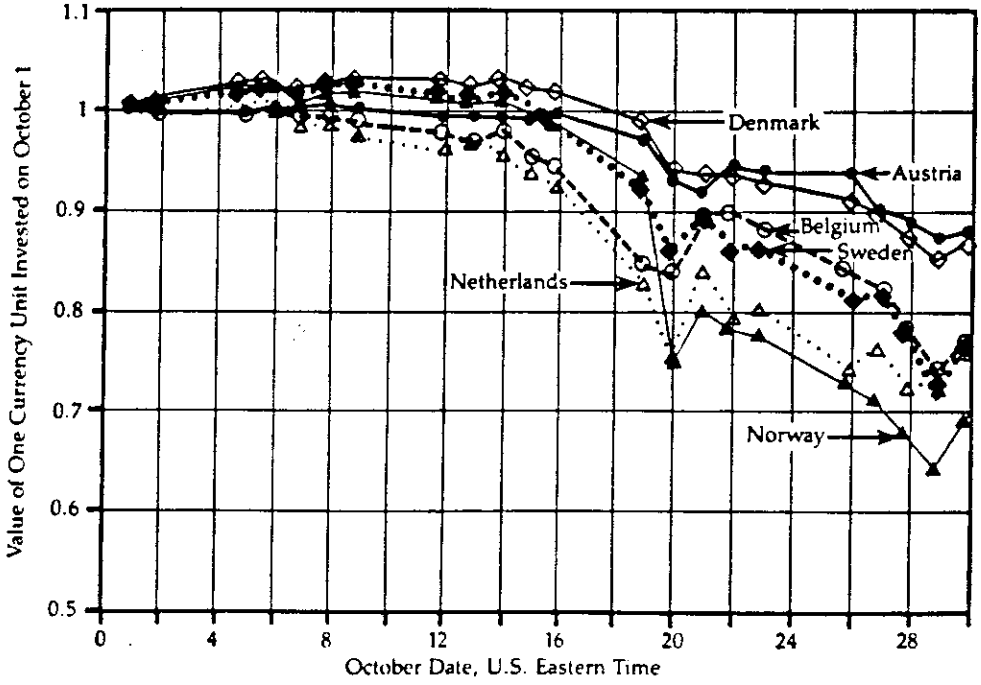


Figure E October 1987 Stock Prices—Asian Markets

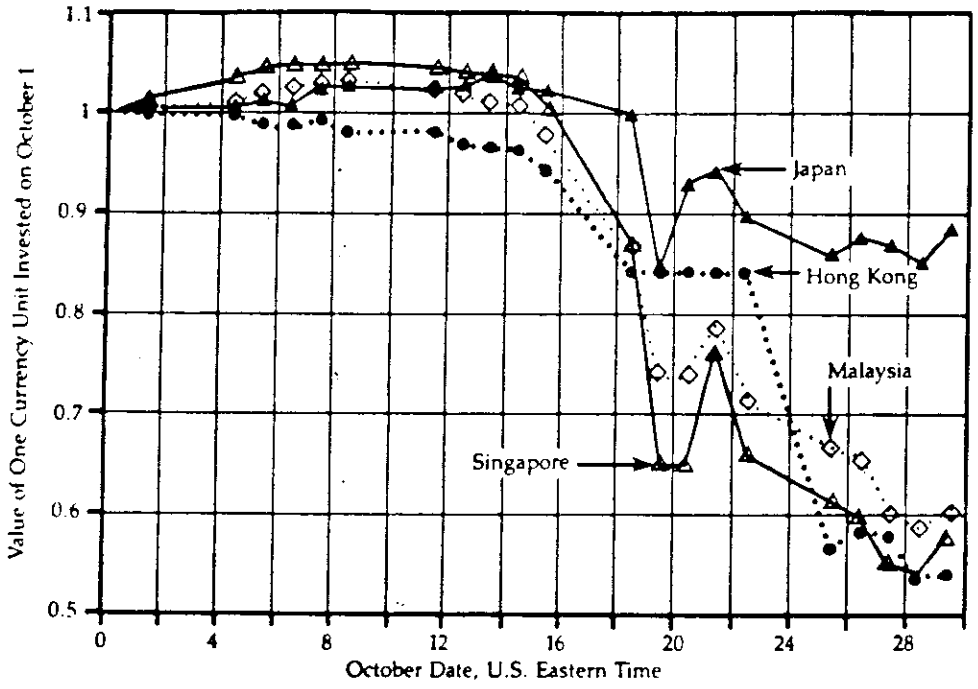


Figure F October 1987 Stock Prices—Australia and New Zealand

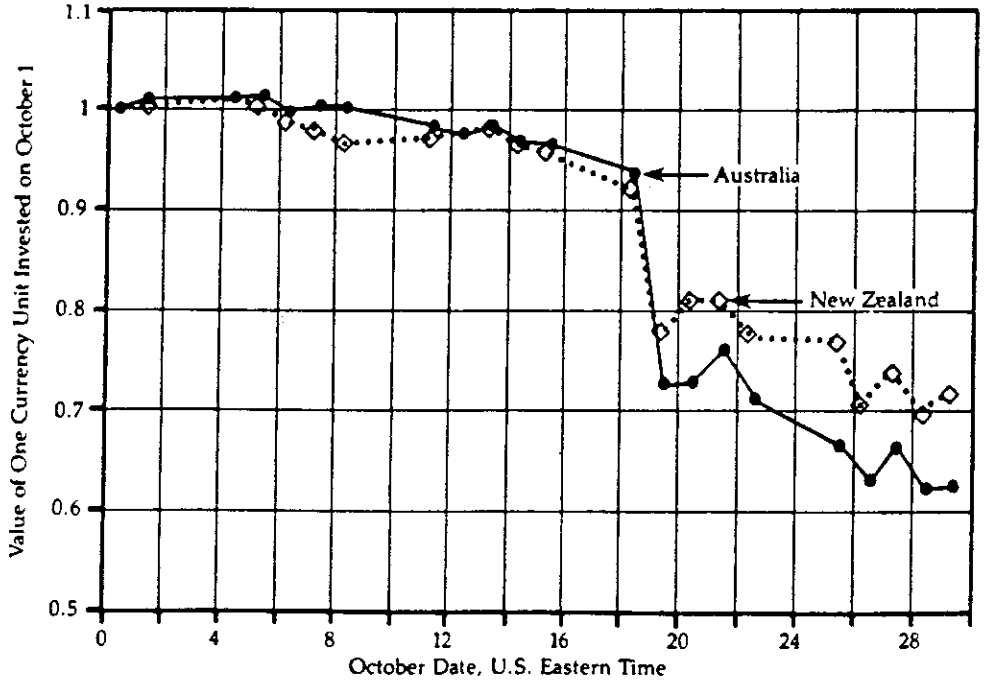


Figure G Regional Indexes—October 14–October 26

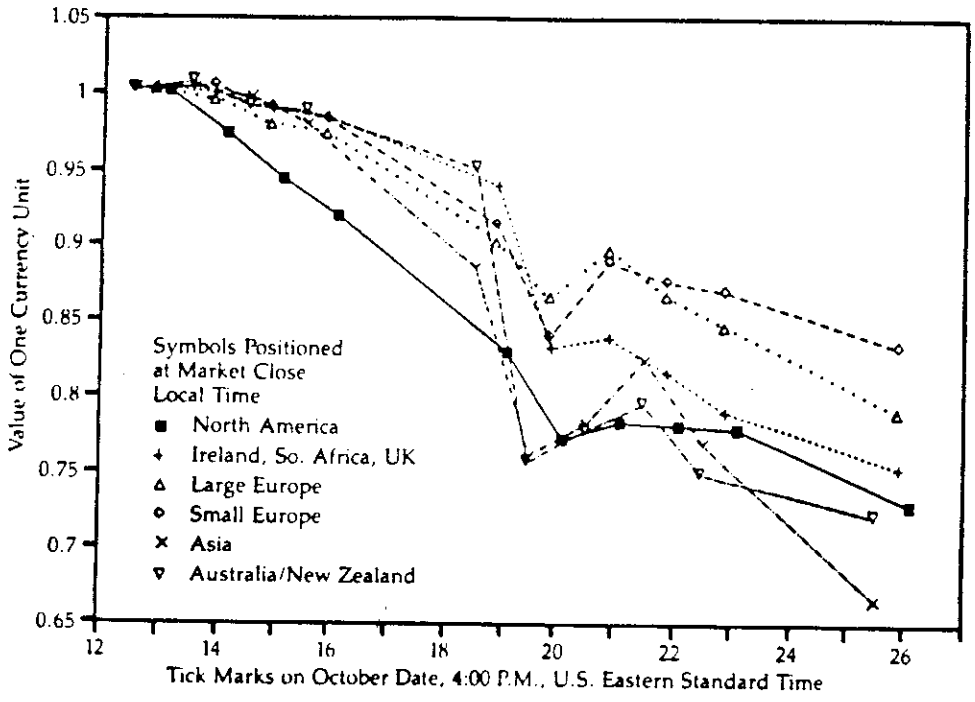
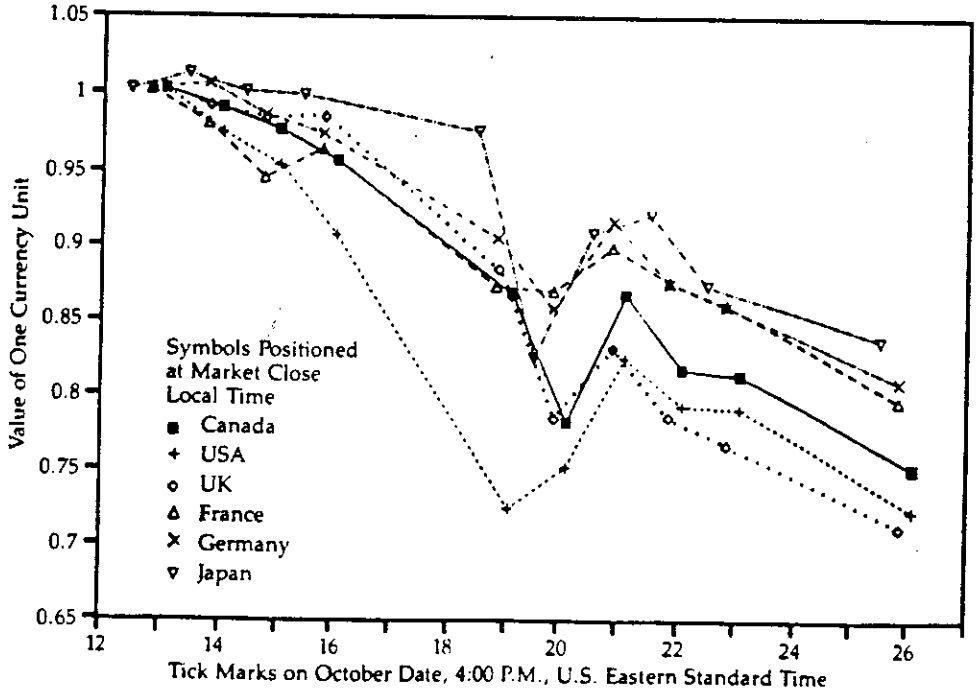


Figure H The Six Largest Markets—October 14–October 26



stock price increases over the January to September period. There was, however, wide disparity in the extent of the advance.

One symptom of a speculative bubble might be an inverse relation between the price increase and the extent of the subsequent crash. Figure I presents a cross-country comparison of the January-September 1987 return versus the October decline.[7] There is in fact a significant negative cross-country relation. The regression line shown on the figure indicates a statistically significant association, with an R^2 of 0.543.

There is, however, a conceptual difficulty in ascribing these results to the existence of a speculative bubble: The same pattern would arise if there were underlying common factors driving stock price changes in all countries. Suppose, for instance, that there is a fundamental macroeconomic factor related to world industrial activity, that it influences the market in every country, but that each country's amplitude of response is different. If that factor happened to be positive from January through September of 1987, while other country-specific influences happened to be relatively stable, we would have observed price advances in most countries (although advances of widely-varying amounts). If the same factor happened to decline dramatically in October, those countries with the greatest amplitude of reaction would have displayed the largest stock price declines. The overall result would be a cross-country negative relation such as that indicated in Figure I. In other words, high "beta" countries do better in worldwide bull markets and worse in bear markets, thus inducing a cross-country negative relation when a bull market period is compared cross-sectionally with a bear market period.

To ascertain whether 1987 was really a speculative bubble followed by a crash, as opposed to a simple manifestation of the usual world market behavior, one would be obliged to identify and estimate a factor model over an entirely different period and use the prefitted response coefficients with fundamental macroeconomic factors measured during 1987.

Since the Crash

In the aftermath of the crash, some have alleged that it was actually an overreaction and that it will soon be reversed; i.e., that it represented just the opposite of a corrected speculative bubble (but was still irrational). If this is true, strong and sharp price increases should occur sometime. However, as Figure J shows, there has been no evidence of a rebound during the successive four calendar months.

Certain regions have performed better than others. Asia, North America and the smaller European countries have experienced moderate price increases, particularly after the first of December 1987. Conversely, other regions (Australia, New Zealand) have performed rather poorly, or have shown little movement in either direction from the level established at the end of October. The interocular test in Figure J reveals an ordinary pattern, one that could be expected over just about any four-month interval—some differences across markets, but certainly no dramatic and worldwide reversal anywhere close to the size of October's decline.

A world index constructed by equally weighting the local currency indexes and normalized to 100 on September 30, 1987 fell to 73.6 by October 30. By February 29, 1988, the index stood at 72.7. Thus the price level established in the October crash seems to have been a virtually unbiased estimate of the average price level over the subsequent four months. If a sizable correction is going to occur, it is apparently going to take a while.

Institutional Arrangements and Market Behavior

Our world laboratory experiment provides insights into the possible influence of each major element of a market's institutional structure. The stock markets around the world are amazingly diverse in their organization. Table III provides a list of some of the particular features in place during October 1987.[8]

Among the features that have figured prominently in post-crash discussions are the extent of computerized trading, the auction system itself, the presence or absence of limits on price movements, regulated margin requirements, and off-market or off-hours trading. Additional features that could be of significance include the presence or absence of floor brokers who conduct trades but are not permitted to invest on their own accounts, the extent of trading in the cash market versus the forward market, the identity of traders (i.e., institutions such as banks or specialized trading firms), and the significance of transaction taxes.

Some markets have trading for both immediate and forward settlement. When forward set-

Figure I 1987 Returns, October vs. January–September

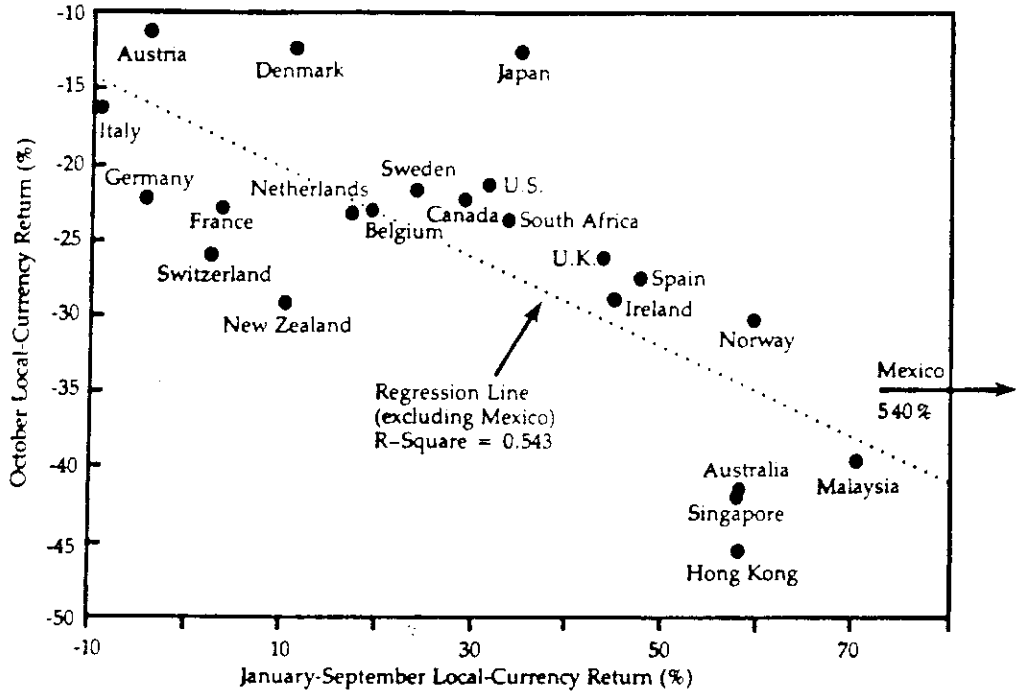


Figure J Regional Indexes—October 14, 1987–February 29, 1988

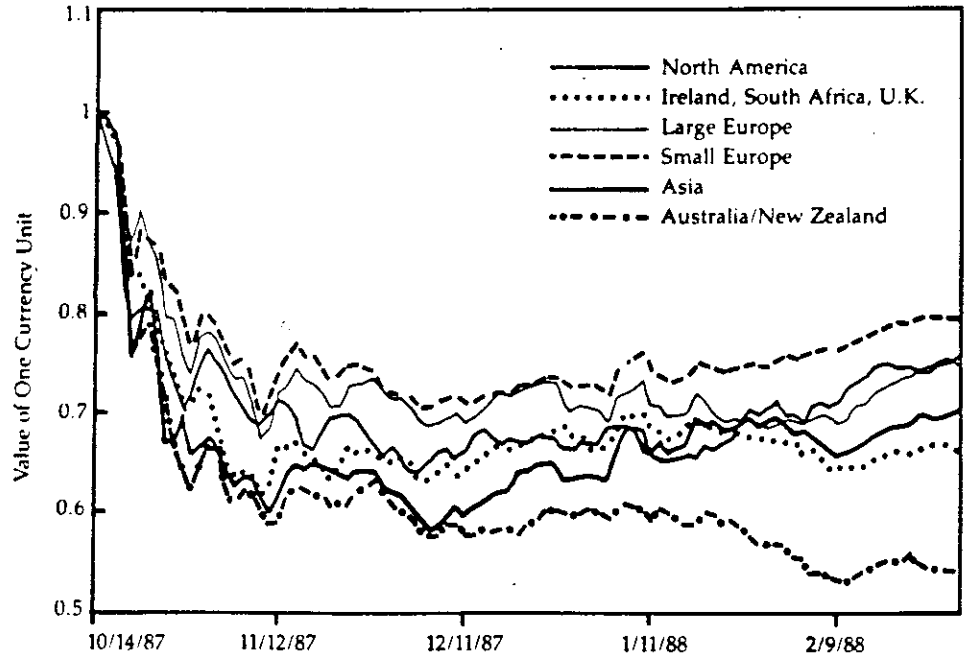


Table III Institutional Arrangements in World Markets

Country	Auction	Official Specialists	Forward Trading on Exchange	Automated Quotations	Computer-Directed Trading	Options/Futures Trading	Price Limits	Transaction Tax (Round-Trip)	Margin Requirements	Trading Off Exchange
Australia	Continuous	No	No	Yes	No	Yes	None	0.6%	None	Infrequent
Austria	Single	Yes	No	No	No	No	5%	0.3%	100%	Frequent
Belgium	Mixed	No	Yes	No	No	No[a]	10%/None[b]	0.375%/0.195%	100%/25%[b]	Occasional
Canada	Continuous	Yes	No	Yes	Yes	Yes	None[c]	0	50%[d]	Prohibited
Denmark	Mixed	No	No	No	No	No	None	1%	None	Frequent
France	Mixed	Yes	Yes	Yes	Yes	Yes	4%/7%[e]	0.3%	100%/20%[f]	Prohibited
Germany	Continuous	Yes	No	No	No	Options	None	0.5%	None	Frequent
Hong Kong	Continuous	No	No	Yes	No	Futures	None[g]	0.6% +	None	Infrequent
Ireland	Continuous	No	No	Yes	No	No	None	1%	100%	Frequent
Italy	Mixed	No	Yes	No	No	No	10–20%[h]	0.3%	100%	Frequent
Japan	Continuous	Yes	No	Yes	Yes	No[i]	−10%	0.55%	70%[j]	Prohibited
Malaysia	Continuous	No	No	Yes	No	No	None	0.03%	None	Occasional
Mexico	Continuous	No	Yes	No	No	No	10%[k]	0	None	Occasional
Netherlands	Continuous	Yes	No	No	No	Options	Variable[l]	2.4%[m]	None	Prohibited
New Zealand	Continuous	No	No	No	No	Futures	None	0	None	Occasional
Norway	Single	No	No	No	No	No	None	1%	100%	Frequent
Singapore	Continuous	No	No	Yes	No	No[n]	None	0.5%	71%	Occasional
South Africa	Continuous	No	No	Yes	No	Options	None	1.5%	100%	Prohibited
Spain	Mixed[o]	No	No	No	No	No	10%[p]	0.11%	50%[p]	Frequent
Sweden	Mixed	No	No	Yes	No	Yes	None	2%	40%	Frequent
Switzerland	Mixed	No	Yes	Yes	No	Yes	5%[q]	0.9%	None	Infrequent
United Kingdom	Continuous	No	No	Yes	Yes	Yes	None	0.5%	None	Occasional
United States	Continuous	Yes	No	Yes	Yes	Yes	None	0	Yes	Occasional

a. Calls only on just five stocks.
b. Cash/forward.
c. None on stocks; 3-5% on index futures.
d. 10% (5%) for uncovered (covered) futures.
e. Cash/forward, but not always enforced.
f. Cash/forward; 40% if forward collateral is stock rather than cash.
g. "Four Spread Rule": offers not permitted more than four ticks from current bids and asks.
h. Hitting limit suspends auction; auction then tried a second time at end of day.
i. Futures on the Nikkei Index are traded in Singapore.
j. Decreased to 50% on October 21, 1987 "to encourage buyers."
k. Trading suspended for successive periods, 15 and then 30 minutes; effective limit: 30–40%.
l. Authorities have discretion. In October, 2% limits every 15 minutes used frequently.
m. For non-dealer transactions only.
n. Only for Nikkei Index (Japan).
o. Groups of stocks are traded continuously for 10 minutes each.
p. Limits raised to 20% and margin to 50% on October 27.
q. Hitting limit causes 15-minute trading suspension. Limits raised to 10–15% in October.

tlement exists, the forward contracts often have a greater volume of trading than cash contracts. For instance, on the Paris *Bourse*, there is a once-a-day auction in the cash market conducted by designated brokerage houses, but there is continuous forward trading in the larger stocks from 9:30 to 11:00 a.m. and repeated call auctions thereafter in forward contracts for all stocks. The limit moves are different too; they are 7 per cent in the forward market and 4 per cent in the cash market.[9] However, there are no limits on the price movements of foreign securities. All trading is done by registered stock brokers, a requirement of French law. Block trading is conducted between the previous day's high and low prices, and block volume constitutes about one-half of all equity trading.

To judge the importance of any particular institutional characteristic, one could compare the market behavior in Table I or in Figures A to F with the presence or absence of the characteristic given in Table III. For example, computer-directed trading is prevalent in Canada, France, Japan, the United Kingdom and the United States. In local-currency terms, these five countries experienced an average decline of 21.25 per

Table IV Local-Currency Returns in October 1987 and Market Characteristics

	Auction	*Official Special.*	*Forward Trading*	*Auto. Quot.*	*Comp. Trading*	*Options/ Futures*	*Price Limits*	*Trans. Tax*	*Margin Reqs.*	*Off-Ex Trading*
	Cont. = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	None = 0 Else = 1	Non-0 = 1 Else = 0	None = 0 Else = 1	None & Infr. = 0 Else = 1
Average October Local-Currency Return for Countries in Zero/One Variable Group (%)										
Group 1	−29.69	−19.53	−24.70	−28.99	−21.25	−27.31	−22.08	−26.31	−23.54	−25.94
Group 0	−21.39	−29.47	−26.93	−23.14	−27.89	−25.50	−29.25	−27.08	−30.22	−27.38
Diff.	−8.31	9.94	2.23	−5.85	6.63	−1.80	7.17	0.78	6.68	1.44
T-Value	−2.66	3.53	0.51	−2.05	2.31	−0.57	2.25	0.22	2.20	0.41
Multiple Regression of October Local Currency Return on Zero/One Variables										
Coeff.	−7.324	6.528	−2.867	−6.065	7.518	1.194	1.638	1.845	2.111	1.452
T-Value	−1.304	1.068	−0.417	−0.954	1.110	0.222	0.232	0.298	0.449	0.258
TS T-Val.	−1.762	1.628	−0.592	−1.287	1.631	0.267	0.335	0.343	0.594	0.406

intercept = −26.5; adjusted R-squared = 0.254

cent during October; the 18 countries without widespread computer-directed trading experienced an average decline of 27.89 per cent. Taken as a characteristic in isolation, computer-directed trading (e.g., portfolio insurance and index arbitrage), if it had any impact at all, actually helped mitigate the market decline.

The Quantitative Impact of Market Arrangements on the Extent of the Crash

To obtain a quantitative estimate of the impact of each qualitative institutional characteristic, we converted the entries in Table III into zero/one values and computed both univariate and multivariate results based on the converted numbers. Table IV defines the zero/one variables and presents the basic results.

The top panel of the table shows simple cross-country means for the countries in each univariate zero/one category. For example, if the auction in a particular country is conducted on a continuous basis, that country is assigned to group 1; if there is a single daily auction, or a mixed auction, the country is in group 0. Table IV shows that continuous-auction countries had October declines of 29.69 per cent on average, while the non-continuous-auction countries had October declines that averaged 21.39 per cent.

The t-value of the difference provides a statistical measure of significance. If the t-value is above 1.65 (in absolute terms), the odds are roughly 10 to one that the variable is significant, when judged on a univariate basis (i.e., in isolation).[10] Six of the 10 variables were related to the magnitude of the crash. Continuous auctions and automated quotation systems were associated with larger declines, while the presence of an official specialist, computer-directed trading, price limits and margin requirements were associated with smaller declines. Forward trading, options and futures trading, transaction taxes and trading off the exchanges were not significantly associated with the size of the crash.

Univariate results may be misleading, however. A characteristic that appears to be significant may merely be a proxy for some other characteristic that is the true cause of the observed difference. This is certainly possible here, not only because the different institutional characteristics are correlated across countries, but also because other relevant influences may have been omitted.

The bottom panel of Table IV presents a multivariate comparison in the form of a cross-country regression of October returns (in local-currency units) on all the zero/one variables. The explained variance (adjusted R^2) was 25.4 per cent, but none of the ordinary t-values from the cross-sectional regression indicates statistical reliability. This reveals the presence of multicollinearity in the explanatory variables, which makes it difficult to assess the relative importance of each one.

Moreover, the observations in this cross-sec-

tional regression may not be cross-sectionally independent, in which case the ordinary t-values will be biased, although the direction of bias is impossible to determine without knowledge of the covariance structure of the residuals. In an attempt to repair both multicollinearity and cross-sectional dependence, we constructed another t-value by using the time series of cross-sectional returns for the period prior to October. The method is explained in the appendix.

With the time-series-derived TS t-values, several characteristics have at least marginal statistical reliability. The presence of an official monopolistic specialist and computer-directed trading were associated with less severe market declines in October. Continuous auctions were marginally significant and associated with greater market declines. Note that these three variables have coefficients with roughly the same magnitude in both the univariate and the multivariate computations, while variables such as price limits and margin requirements have much larger coefficients in the univariate calculations.[11]

Although the regression in Table IV indicates some statistically significant associations between certain market characteristics and the October decline, one should hesitate to conclude that even a strongly associated variable actually contributed to the decline. Markets differ in their amplitudes of response to the same underlying trigger, and certain institutional features may have been adopted because of a high amplitude. For example, it is conceivable, though perhaps improbable, that price limits are abandoned in markets with great volatility. This could have given rise to an association between the absence of price limits and the severity of price decline in October 1987, without there actually having been a mitigating influence of limits.

The Typical Market Response to World Movements and the Crash

In addition to institutional arrangements, another potential explanation for the variety of declines in different markets is that a fundamental, worldwide triggering variable caused the crash, and that the relative movement of each market was simply the usual relation between that particular market and the underlying factor. In order to assess this possibility, we used data from February 1981 through September 1987 to construct a world market index.[12] The index was equally weighted across countries using local-currency-denominated returns.[13] The following simple market model was fitted to the available time series of monthly returns for each country:

$$R_{j,t} = a_j + b_j R_{M,t} + e_{j,t},$$

where

$R_{j,t}$ = the monthly percentage change in the index of country j for month t,
$R_{M,t}$ = the world market index percentage change,
$e_{j,t}$ = an unexplained residual, and
a_j and b_j = fitted coefficients.

The slope coefficient b_j is the so-called beta, which measures the relative magnitude of response of a given country to changes in the world market index. The appendix gives details of these regressions for each country. Every country exhibited a statistically significant relation with the world market index, with the average R-square being 0.243.

The market model fitted for each country up through September 1987 was used to predict the country's return in October 1987, conditional on the world market index movement in October. The prediction errors (or out-of-sample residuals) were then related cross-sectionally to market characteristics (i.e., to the zero/one variables used previously). The top panel of Table V gives the results.

No coefficient is statistically different from zero. Thus none of the institutional market characteristics was associated with an unusually large or small October return after the worldwide market movement was taken into account. In other words, the magnitude of each market's decline was explained by that market's ordinary relation with world market events. Nothing was left to be explained by the particular institutional arrangements in place.[14]

The second panel of Table V gives some additional evidence about the overwhelming influence of the world market "factor." In the cross-sectional regression reported there, the October index return (not the residual) was related to the institutional zero/one characteristics plus the market-model slope coefficient (or beta) from the time-series regression for each country calculated up through September. This panel differs from the cross-sectional multiple

Table V Local Currency Market Model and Market Characteristics

	Auction	*Off. Special.*	*Forward Trading*	*Auto. Quot.*	*Comp. Trading*	*Options/ Futures*	*Price Limits*	*Trans. Tax*	*Margin Reqs.*	*Off-Ex. Trading*	*Beta*
	Cont. = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	Yes = 1 Else = 0	None = 0 Else = 0	Non-0 = 1 Else = 0	None = 0 Else = 0	None & Infr. = 0 Else = 1	
Market Model Prediction Errors in October 1987 vs. Market Characteristics											
Coeff.	1.688	3.540	8.529	−4.381	1.670	−3.614	−2.201	−5.669	0.551	−0.951	
T-Value	0.361	0.697	1.491	−0.828	0.297	−0.809	−0.376	−1.103	0.141	−0.203	
intercept = 5.89; adjusted R-squared = 0.088											
Multiple Regression of October Local-Currency Return on Zero/One Variables and on Typical Response											
Coeff.	−1.443	4.010	4.080	−5.460	4.218	−1.476	0.020	−3.088	1.338	0.179	−16.642
T-Value	−0.281	0.786	0.654	−1.046	0.741	−0.326	0.003	−0.571	0.346	0.039	−2.615
TS T-Val.	−0.351	1.046	0.779	−1.169	0.945	−0.339	0.004	−0.638	0.387	0.049	−2.251
intercept = 6.42; adjusted R-squared = 0.498											
Market Model Betas, January 1981–September 1987 vs. Market Characteristics											
Coeff.	0.353	−0.151	0.417	0.036	−0.198	−0.160	−0.097	−0.296	−0.046	−0.077	
T-Value	1.691	−0.665	1.631	0.154	−0.787	−0.803	−0.371	−1.288	−0.266	−0.366	
intercept = 1.21; adjusted R-squared = 0.255											

regression in Table IV only by the inclusion of the beta. Comparing the two regressions, we observe that none of the market characteristics remains even marginally significant. In contrast, the beta is highly significant, and its coefficient (−16.6 per cent) is a large fraction of the average world market portfolio return.[15] It is more than four times the magnitude of any other estimated coefficient in the regression.

Because this regression uses total percentage changes during October, it may be subject to cross-sectional dependence. A time-series t-value was computed, using the methods described in the appendix. The results are qualitatively the same: Only the market-model beta is statistically significant in explaining October 1987 returns.

There is one remaining problem: It seems at least conceivable that the typical magnitude of response of a given country to a world market movement is itself a function of the institutional arrangements in that country's stock market. For example, perhaps margin requirements or limits on price movements reduce the market-model beta relative to the level it would otherwise achieve in their absence. If so, the dominance of the beta in the October-return cross-sectional regression in Table V and the absence of a statistically significant market characteristic in the cross-sectional regression for market-model residuals during October may still not entirely remove the suspicion that some of the institutional arrangements had an influence on the crash. Instead of showing up directly, their influence could have been exerted by reducing or increasing the estimated magnitude of response.

To check out this possibility, we computed another cross-sectional regression, this time with the dependent variable being the estimated beta itself and the explanatory variables the zero/one market characteristics. The bottom panel of Table V reports the results.

Two characteristics are marginally significant—continuous auctions and forward trading. Forward trading, however, did not show up as an influence on either the total returns in October or on the October market-model residuals. Although it may be an influence on the typical response of a market to world movements, it does not seem to have played a role in the crash. Continuous trading, however, may be a culprit. Countries whose stock markets conduct continuous auctions did worse during the crash. These markets are also associated

with larger betas, hence tend to swing more widely in response to worldwide market influences.

If we were willing to accept this result as evidence of causation, we might go on to speculate on why continuous auctions might be prone to larger price swings. A continuous auction conducts trading throughout the day, as orders are received, while a non-continuous auction collects orders over a 24-hour interval and clears all of them at a given time. The continuous auction is more dynamic, and it certainly offers a larger inducement for a trader to act quickly. Quick decisions are less important in a non-continuous regime, because others may reach similar conclusions before the appointed time for the auction. Acting quickly, in an attempt to beat others to the next trade, could lead to more frequent errors and even to panic. Perhaps haste made waste in October 1987.

Market Liquidity

"Liquidity" may have influenced country responses during the crash. Liquidity is not a well-defined term, but most market observers seem to regard smaller markets as less liquid, hence prone to greater price volatility, susceptible to psychological influences, and probably less "efficient." To examine this idea, we used the aggregate dollar value of stocks traded on each stock exchange as a proxy for liquidity.

On September 30, 1987, the 23 national markets in our database differed widely in aggregate capitalization. The smallest was Norway ($2.65 billion) the largest Japan ($2.03 trillion). The United States market capitalization was $1.85 trillion.

Because market capitalization differs across countries by a factor of almost 100, we used its logarithm in the statistical estimation. Log (Market Cap) was included along with the zero/one institutional characteristics and the estimated market-model beta to explain the cross-sectional differences in return during October 1987. It was completely insignificant, having a t-value of only 0.348, and left all the other coefficients virtually unchanged.[16]

Given the previous information about returns around the crash, the lack of a liquidity effect is probably not all that surprising. Some of the smallest markets (Austria and Denmark) performed relatively well in October, while others (Malaysia and Mexico) did poorly. Similarly, some larger countries (Japan) had small declines, while others (the U.K.) were more severely affected. The relative extent of the October crash was related to characteristics other than sheer size. ■

Footnotes

1. The data source was Goldman, Sachs & Co., "FT-Actuaries World Indices," various monthly editions. The indexes are the most widely followed in each country. A complete list of each country is contained in Goldman, Sachs & Co., "Anatomy of the World's Equity Markets."
2. Between Canada and the U.S. and between Malaysia and Singapore.
3. The previous 76 months go from June 1981 through September 1987.
4. For example, Tokyo is 14 hours ahead of New York, so its observation for October 1, Tokyo time, is plotted as October 0.41666 (i.e., 10/24) New York time. The non-Japanese Asian markets are plotted according to Japanese time, although they are one hour later. Similarly, Mexico is plotted New York time, South Africa is plotted British time, and New Zealand is plotted Australian time. Mexico is one hour behind New York; South Africa and New Zealand are two hours ahead of Britain and Australia, respectively.
5. As Figures G and H show, most other markets did decline even earlier than the U.S. on each day from the 14th through the 16th.
6. Canada's decline from October 22 through October 30 was only 1.62 per cent. Thirteen countries had at least 10 per cent declines in this period.
7. Mexico was excluded from the figure and the regression line because its return during January–September 1987 was 540 per cent in local currency units (although only 271 per cent in dollars); it seems to be an outlier.
8. The data presented in Table III are not easily available. Jim Brandon telephoned every country on the list and interviewed a person knowledgeable about each market. The author thanks Neville Thomas and Michael Crowley, Australia; Robert Schwind, Austria; Mme. Moeremhout, Belgium; Jim Darcel, Canada; Jorgan Brisson, Denmark; M. Douzy, France; Michael Hanke, Germany; Patrick Leong, Hong Kong; Tom Healy, Ireland; Alessandro Wagner, Italy; Moriyuki Iwanaga, Japan; Mr. Izlen, Malaysia; Armando Denegas, Mexico; Paul Koster, The Netherlands; Cathy Gruschow, New Zealand; Melvin Tagen, Norway; Gillian Tam, Singapore; Mrs. De Kock, South Africa; David Jimenez, Spain; Les Vindeyaag, Sweden; Brigette Borsch, Switzerland; and Matthew Hall, United Kingdom.
9. The French market exhibits a unique concept of price limits. They are not enforced if the entire

market seems to be moving in the same direction. According to our informant, enforcement applies only when an individual stock "appears to be manipulated."

10. An explanation of the statistical methods used to obtain the t-value is contained in the appendix.
11. The univariate difference in means across zero/one groups is identical to the slope coefficient in a cross-sectional regression of the October return on a single zero/one variable (for a proof, see the appendix). Thus the effect of multicollinearity can be directly gauged by comparing the slope coefficient in the second panel of Table IV with the corresponding group mean differences in the first.
12. Goldman, Sachs & Co. provided monthly market index levels beginning in January 1981. However, their database does not include Mexico until May 1981. The first month is lost by calculating the monthly percentage change in the index. Thus the index includes 22 countries from February 1981 and 23 countries from June 1981. Dividend yields are available for the latter part of the data period, but dividends have little variability and were thus omitted from the calculations without harm. Because of this omission, the index percentage change for a given month differs slightly from the monthly total return.
13. Indexes were actually constructed both on a common-currency basis and a local-currency basis, and both equally weighted and value-weighted (by the dollar value of total country capitalization). Time-series regressions between individual country returns and the various indexes yielded surprisingly similar slope coefficients (betas). There were differences in R-squares, of course, because the exchange rate adjustment essentially adds a noisy but relatively uncorrelated random variable to the local-currency return. The intercepts also differed, by roughly the difference in mean returns in local currency and in dollars.
14. Note that cross-sectional dependence is probably not material in this regression, simply because the principal source of that dependence, general worldwide market movements, has already been removed.
15. Even this coefficient is probably understated in absolute magnitude because the beta is only an estimated coefficient and is thus an error-contaminated regressor.
16. In particular, the coefficient of beta was about the same (−15.6) and still highly significant (t-value of −2.16). Cross-sectionally, the beta estimated from February 1981 through September 1987 is moderately correlated with the log of market capitalization at the end of September 1987. A cross-sectional regression of beta on log size gives a slope coefficient of −0.147 with a t-value of 1.68. But when both variables compete in a cross-sectional regression predicting the October decline, the beta wins in the sense of being uniquely significant.

Appendix

T-Values for the Univariate Differences

For each institutional characteristic, two portfolios were formed corresponding to whether the group variable was zero or one. As an example, when the institutional characteristic was computer-directed trading, the first portfolio consisted of an equal-weighted combination of the countries with computer–directed trading (Canada, France, Japan, the United Kingdom and the United States, from Table III), and the second portfolio consisted of an equal-weighted combination of the other countries (the 18 without computer-directed trading). There is a total of 20 such portfolios, two for each of 10 institutional characteristics.

The return for each of the 20 portfolios was calculated for all available data periods before October 1987. Except for Mexico, this was February 1981 through September 1987. For Mexico, it was June 1981 through September 1987. Thus, during the first four of 80 months, Mexico was missing from the 10 portfolios to which it later belonged.

For each month and each institutional characteristic, a return difference was formed by subtracting the portfolio return for group 0 from the portfolio return for group 1. This is tantamount to buying long those countries with a "1" and shorting those countries with a "0" *for a particular characteristic*. There were thus 10 time series of return differences, one for each institutional characteristic.

The standard deviation of the return difference was calculated from the 10 time series. Finally, the t-value was calculated as the return difference in October 1987 divided by the calculated time-series standard deviation.

Univariate Regression

The slope coefficient from the regression of y on a zero/one variable x is simply the difference in group means of y. For proof of this, consider the following definitions:

N = total sample size,
n = number of observations, with $x = 1$,
$p = n/N$ and
Y, Y_1, Y_0 = respectively, the sample mean of y, y with $x = 1$, and y with $x = 0$.

Then it is straightforward to show that the ordinary-least-squares bivariate regression slope coefficient of y on x is:

$$b = [p(Y_1 - Y)]/[p(1 - p)],$$
$$= \{Y_1 - [pY_1 + (1 - p)Y_0]\}/(1 - p)$$
$$= Y_1 - Y_0.$$

Time-Series T-Values

The second panels of Tables IV and V present t-values obtained from a time series not including the cross-section month (October 1987). For every month when all countries had available data (June 1981 through September 1987), a cross-sectional multiple regression was calculated between the actual monthly index percentage changes and the explanatory variables, the zero/one variables (corresponding to Table IV), and the zero/one variables plus the country's market model beta (corresponding to Table V). The vector of 10 (11) cross-sectional coefficients corresponding to panel 2 of Table IV (Table V) for month t formed a single time-series observation.

The standard deviation of each element in the vector of coefficients was then computed across all time-series observations. The TS t-value was the estimated cross-sectional coefficient in October 1987 divided by its corresponding standard deviation as computed in steps 1 and 2.

Market–Model Results

Table AI gives means, standard deviations and market-model regression results for local-currency returns, using an equal-weighted, local-currency world market index.

Table AI Local-Currency Index Percentage Changes and Equal-Weighted World Portfolio (Feb.1981–Sept. 1987)

Country	Sample Size (months)	Average % Change (per month)	Standard Deviation (%/month)	Market Model Regression		
				Slope (t-values)	Intercept (t-values)	Adjusted R-Squared
Australia	80	1.634	5.896	1.218 (7.208)	−0.563 (−0.938)	0.3921
Austria	80	0.985	5.128	0.563 (3.152)	−0.031 (−0.048)	0.1016
Belgium	80	1.899	5.191	0.808 (4.785)	0.442 (0.736)	0.2170
Canada	80	0.855	4.931	1.116 (8.492)	−1.159 (−2.481)	0.4738
Denmark	80	1.463	5.306	0.579 (3.127)	0.419 (0.637)	0.1000
France	80	1.748	5.602	0.901 (4.995)	0.123 (0.191)	0.2326
Germany	80	1.503	4.923	0.739 (4.567)	0.171 (0.297)	0.2009
Hong Kong	80	1.439	9.248	1.533 (5.201)	−1.326 (−1.266)	0.2480
Ireland	80	1.926	6.445	1.193 (6.074)	−0.226 (−0.324)	0.3124
Italy	80	1.911	7.783	1.192 (4.688)	−0.240 (−0.266)	0.2098
Japan	80	1.989	4.651	0.557 (3.483)	0.983 (1.729)	0.1235
Malaysia	80	0.433	8.108	1.137 (4.197)	−1.618 (−1.681)	0.1738
Mexico	76	6.555	16.110	2.135 (3.914)	2.655 (1.345)	0.1603
Netherlands	80	1.529	4.988	1.050 (7.440)	−0.365 (−0.728)	0.4076
New Zealand	80	2.190	6.609	1.019 (4.726)	0.352 (0.460)	0.2127
Norway	80	1.656	6.381	1.110 (5.553)	−0.346 (−0.487)	0.2742
Singapore	80	0.874	7.858	1.251 (4.930)	−1.383 (−1.534)	0.2278
South Africa	80	2.181	7.247	0.713 (2.790)	0.895 (0.985)	0.0791
Spain	80	2.352	6.443	0.716 (3.196)	1.060 (1.331)	0.1045
Sweden	80	2.513	6.109	0.872 (4.290)	0.940 (1.302)	0.1805
Switzerland	80	1.010	3.876	0.795 (7.117)	−0.424 (−1.068)	0.3860
United Kingdom	80	1.888	4.567	0.950 (7.288)	0.176 (0.379)	0.3975
United States	80	1.221	4.243	0.856 (6.933)	−0.324 (−0.738)	0.3734