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by B. Lauterbach and Uri Ben-Zion

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PANIC BEHAVIOR AND THE PERFORMANCE OF CIRCUIT BREAKERS: EMPIRICAL EVIDENCE

by

Beni Lauterbach and Uri Ben-Zion*

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* School of Business Administration, Bar Ilan University, 52900 Ramat Gan, ISRAEL, and Faculty of Industrial Engineering and Management, Technion, 32000 Haifa, ISRAEL, respectively. The paper has benefited from presentations at the 1991 European Finance Association Meetings (Rotterdam), the 1991 Econometric Society European Meetings (Cambridge), Bar-Ilan University, Erasmus University, Hebrew University, the University of Pittsburgh, and the University of Tilburg. Sam Brunfeld (Chairman of the Tel-Aviv Stock Exchange), two anonymous referees and René Stulz (the Editor) offered many helpful comments. Any remaining errors are our responsibility. Financial support from the Technion Vice President Research Fund is gratefully acknowledged.

Panic Behavior and the Performance of Circuit Breakers: Empirical Evidence

Abstract

The study examines the behavior of a small stock market with circuit breakers and with a one-hour pre-auction order imbalance disclosure, during the October 1987 crash. The crash and its aftershocks lasted for a week and selling pressure was concentrated in higher beta, larger capitalization, and lower leverage firm stocks. Circuit breakers when implemented reduced the next-day opening order imbalance and the initial price loss; however, they had no effect on the long-run response. Some price overreaction and reversal phenomena also are documented.

Introduction

The October 1987 crash was the most prominent recent example of panic in stock markets.[1] The crash was worldwide. Roll (1988) notes that: "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 by more than 20%."

Following the crash, the Presidential Task Force on Market Mechanisms (the Brady Commission) recommended that: "Circuit breaker mechanisms (such as price limits and coordinated trading halts) should be formulated and implemented to protect the market system (1988, p. 130)." The commission's hope was that circuit breakers followed by orderly re-opening procedures would dampen the enormous intraday volatility of prices characteristic of crash days, and would enable the stock exchanges to execute the public's orders more efficiently (see Greenwald and Stein (1988)).

There is little unanimity on the issue of circuit breakers. Given their obvious cost -- interfering with market liquidity -- the effectiveness of circuit breakers needs to be more clearly demonstrated. Previous empirical

research such as Roll (1989), and Ma, Rao, and Sears (1989) present some interesting observations on the issue. Further evidence, based on the unique experience of the Israeli stock market during the October 1987 crash, is provided hereafter.

There are three main contributions in examining Israeli data. First, on the crash day of 1987, the Tel-Aviv Stock Exchange implemented circuit breakers selectively: not all Israeli stocks had trade halts because of limit movements; about a third of the stocks managed to trade. This circumstance enables a controlled examination of the effect that circuit breakers have. In fact, some of the stocks had more than one auction on the crash day. Hence, the "trading on crash day" variable becomes multi-level and richer in implications.

Second, during the crash period the Tel-Aviv Stock Exchange announced order imbalance for each stock an hour before trade started, and imbalance offsetting orders were received until the auction itself. This procedure of an open period before trade when public and traders can submit offsetting orders is akin to the trading mechanism that Greenwald and Stein (1991) recommended to deal with panic situations. It is interesting to examine whether or not panic and overreaction occur in such a controlled environment.

Finally, there is the data advantage. The Tel Aviv Stock Exchange (TASE) publishes daily initial (pre-auction) order imbalances for each stock. We therefore have accurate order imbalance measures of a kind not available in previous research (see Blume, MacKinlay, and Terker (1989), for example). The accuracy of these data increases the reliability of the analysis and allows an exploratory investigation of the determinants of order imbalance in panic situations. This is the first study to examine explicit order imbalance data, and it is arguable that the results of such an analysis are more revealing than price response analysis alone.

I. Research Issues

A. Panic Behavior

Ben-Zion, Gutman, Egbe, and Brahams (1990) have studied the relative trading volumes of S&P 500 stocks during the October 1987 crash. Trading volumes increased especially for smaller-capitalization stocks, higher-risk stocks, and stocks that had gained the most from January through September of 1987. To the extent that trading volumes during the crash are indicators of supply pressures, this evidence suggests that investors attempted to sell the more uncertain and less established stocks.

The present study contributes to panic-behavior description by examining explicit and highly accurate order imbalance data. We construct a measure of the crash-day relative order imbalance, defined as the order imbalance of the stock on crash day divided by the normal level of absolute imbalance in the stock. This measure indicates which stocks are disproportionately dumped during a panic, information which could hint at reasons behind a panic and reveal major concerns of investors at the time.

B. Circuit Breakers

Crashes are also characterized by an unusual intraday price volatility. The large price swings occurring within minutes create serious information asymmetry problems between floor traders and the public. Most investors can no longer be sure about the order execution price; hence they may refrain from trading altogether. Consequently, prices become even more chaotic. A trade halt could put an end to this vicious circle by giving investors a chance to reassess the circumstances, get information about the order imbalances, and organize liquidity for their trading plans. In short, trade halts followed by an orderly "open" procedure should restore the informativeness of and confidence in market prices (see Greenwald and Stein (1988, 1991)).

Despite the logic behind circuit breakers, empirical studies on their actual effects have been scarce. Ma, Rao, and Sears (1989) examine the impact of hitting price limits on the return and volume behavior of four future contracts (Treasury bonds, silver, corn, and soybeans). They find that following a limit move: 1) prices tend to stabilize or even reverse direction, 2) the volatility of prices decreases, and 3) volume of trade remains unchanged. Ma, Rao, and Sears' general impression is that price limits serve a positive role, in that they cool off market reaction without imposing any substantial cost.

Stock price evidence on the performance of circuit breakers is scant, and the results appear mixed. In a comparative study of the October 1987 declines of 23 major stock markets in the world, Roll (1988) finds that price limits have no significant impact on the decline. Bertero and Mayer using daily data for the same 23 markets as Roll, conclude by contrast that: "Markets that had circuit breakers in operation on average decline by 7% and 9% (depending on the period) less than those that did not (1990, p. 1167)."

While there may be ways to explain the discrepencies in evidence (Roll and Bertero and Mayer use different explanatory variables and different return windows - see Roll (1989) p. 232), the divergent results highlight a basic problem of cross-country research: the data set is small and heterogeneous. Trading mechanisms in international markets differ from one another in numerous aspects, so measuring the effect of circuit breakers is problematic.

The present research attempts to infer circuit breaker effectiveness by studying a more homogeneous environment - the Tel Aviv Stock Exchange. The focus on a single exchange allows comparison of return and order imbalance data of stocks that traded on crash day with stocks that did not (i.e., stocks that had trade halts) in a relatively controlled fashion.

II. Data

A. The Sample

The study uses stock return, order imbalance, and firm-characteristic data. Stock return and order imbalance data are collected from the Official Daily Quote Sheet published by the TASE. Data are daily for the period October 13-28, 1987. This wide window is designed to provide a reliable description of stock behavior before, during, and after the crash.

In October 1987 250 different company common stocks traded on the TASE. Excluding stocks that were not on the main list of the exchange and stocks that did not trade on at least three out of the ten trading days in the sample reduces the sample size to 187. Where stocks trade in two classes, we use the one that traded at higher volume in 1986.

The firm and stock characteristic data, which come from Meitav Stock Guide or are derived from stock returns are: the size (total assets), profitability (return on equity), and book leverage of the firm, and the beta and year-to-date gain of the stock. The Appendix details the definitions, measurement procedures, and averages of these variables. While this list of characteristics is by no means exhaustive, we believe it suffices to capture some important facets of behavior during a crash.

B. Trading Mechanisms on the Tel Aviv Stock Exchange

Trade on the TASE is organized in three main stages: pre-auction, auction, and post-auction. The first stage starts at 10:30 AM when exchange members submit their own and the public's market and limit orders to the exchange official. This start time gives investors an opportunity to submit orders in the early morning hours.

Before 10:45 AM the exchange issues a "leader" detailing the initial excess demand or supply for each stock. This figure is calculated by summing all market orders with all limit orders that can be executed at the "basis"

price. The "basis" price is the previous-day closing price on all days except for ex-days. On ex-days (ex-dividend, ex-stock dividend, or ex-rights days), the "basis" price equals the previous-day closing price minus the estimated value of the distribution.

After the first "leader" publication and up until 11:30 AM, the exchange accepts only offsetting orders, i.e., orders against the initial gap. Toward 11:30 AM the exchange publishes a second leader detailing the remaining supply and demand gaps. This updated imbalance as published by the exchange in its official quote sheet is the source of our order imbalance data.

The second stage of trade is the public auction. The auctioneer announces the order imbalance in stock A at the "basis" price and invites exchange members and the public to submit orders against the gap. The auctioneer then raises/reduces stock A's price (in steps of 0.25%) until the imbalance is completely offset.

If there is excess demand for stock A at the "basis" price of 100, for example, the auctioneer raises its price until the "sell" orders received cover the entire gap.[2] The resulting price is called the auction closing price, and all stock transactions are executed at that price. That is, if the auction closing price of A is 100.5, all transactions in A are executed at the price of 100.5. Even if trader Z enters a sell order for A when the auctioneer tries a price of 100.25, Z's stock will be sold at the equilibrium price of 100.5.

The auction closing price is the daily closing price for all but 25 stocks. (These 25 stocks are discussed later.) Daily closing prices are published in the Official Daily Quote Sheet, and are the basis for return calculations in this study.

On occasion, equilibrium in the auction cannot be established even at a price change of 10%. In this instance, trade in the security is halted, the

stock is posted as "sellers only" or "buyers only," and none of the orders submitted is executed. All orders in the stock are cancelled, and a price change of 5% is posted.

For example, if excess demand for stock A is not covered even at a price of 110, the price of A is set at 105, and all orders submitted are voided. According to the TASE regulation, a stock can be listed as "sellers only" or "buyers only" for no more than two consecutive days. After two consecutive "buyers only" or "sellers only" days, an unlimited fluctuation in the stock price is allowed.

Following the public auction of all stocks, a third stage of trade commences. This stage is limited to the Mishtanim stocks - a select group of heavily traded stocks that on October 1987 included 25 stocks. During this stage, bilateral transactions between exchange members take place at variable prices. An official of the exchange announces which Mishtanim stock is to be traded, and then buy and sell offers are entered by the members. Any member can accept any standing offer, and the exchange official records the exact terms of each transaction. Prices are variable. For example, if member Z offers to sell 500 shares of stock B at 100.50 and member Y offers to sell 1000 shares at 100.75, member X can buy 500 shares from Z at 100.50 and 500 shares from Y at 100.75.

The bilateral trading stage continues for up to two and a half hours, and every few minutes another stock trades. Most of the orders come from large traders in the public who use exchange members as brokers, and usually there are several rounds of trade in each of the Mishtanim stocks. The closing price of a Mishtanim stock as reported in the official quote sheet is the average price of the last three bilateral transactions in the stock. The total daily limit movement allowed in a Mishtanim stock is 12%.

III. Evidence on Panic Behavior

A. The October 1987 Crash in Israel

Table I presents a few summary statistics on Israeli market activity and volatility around the crash. Unusual order imbalances and volumes of trade are evident in the period 10/19/1987 through 10/25/1987, and abnormal price swings occured in the period 10/20/1987 through 10/25/1987. Thus, the instability in Israel started on October 19, 1987, a few hours before the U.S. markets opened, and lasted for about a week.[3]

[Table I about here]

The average total loss of the TASE stocks during the crash week is about 15%; their average October 1987 drop is about 18%. This decline is relatively modest by international standards. In Roll's (1988) sample of 23 foreign markets, the median October 1987 drop is 24%. (The U.S. market lost 22%.)

B. Relative Order Imbalances During the Crash

Analysis of relative order imbalances (see the Appendix for exact definitions and computation formulae) is a direct mean of investigating investor behavior in panic situations. Relative order imbalances reveal which securities the public dumped and at what intensity.

Table II summarizes regressions of relative order imbalances on six independent variables: size, profitability, and leverage of the company, and beta, pre-crash gain, and previous-day excess return of the stock. The most interesting results appear on the crash day. On the crash day (October 20, 1987 in Israel), the coefficients of beta and size are significantly negative, and the coefficient of leverage is significantly positive.

[Table II about here]

Interpretation of the crash day results requires some care. Relative order imbalance, the dependent variable in the regression, is a signed

variable (see the Appendix). It is positive in days of excess demand and negative in days of excess supply. October 20, 1987 was a day of overwhelming excess supply. Thus, the negative coefficient of beta in the October 20 regression implies that higher beta stocks had more negative relative order imbalances, i.e., stronger excess supplies, on crash day. Similarly, the negative coefficient of size and positive coefficient of leverage indicate that larger firm stocks and lower leverage firm stocks had stronger supply pressures (more negative order imbalances) on crash day.

Various robustness tests confirm the findings of Table II.[4] It appears that in addition to attempting to reduce their systematic risk, investors also fled on crash day from what seem to have been their "better quality" (larger firm and lower leverage) stocks.

There are two possible interpretations of this phenomenon. First, it might be that the panicking investors held primarily "solid" stocks. If holders of speculative stocks are more tolerant of price fluctuations than holders of solid stocks, the relative bailing out pressure in the solid stocks could be larger. This is essentially a differential panic hypothesis.

The alternative explanation is the rational selling hypothesis. In crash periods, investors attempt to sell their better stocks because they assume that their other stocks are likely to sell at a greater loss. This pattern of behavior is particularly common for mutual funds trying to accommodate large sudden redemptions.

Another interesting day in the sample period is October 25, 1987, when selling pressures were concentrated in smaller-size and higher-leverage stocks. This pattern constitutes a partial reversal of the crash day behavior.

A review of the adjusted R^2s in Table II highlights the unusual crash behavior. On the days before and after the crash (October 13 through 19, and October 26 through 28) adjusted R^2s are close to zero, indicating that stock

characteristics do not explain order imbalances. On crash days, in contrast, adjusted R^2s average 0.21.

C. Price Overreaction and Return Reversal

Blume, MacKinlay, and Terker (1989) document price overreaction and return reversal in U.S. stocks during the crash. To test for these phenomena in our sample, we regress stock returns on beta, size, cumulative gain prior to the crash, relative order imbalance, and previous-day excess return. The first four explanatory variables describe the normal behavior of the stock, while the last one measures the abnormal behavior.[5] The price overreaction and reversal hypothesis predicts that on the day following an overreaction, the coefficient of the previous-day excess return will be negative.

The results of the return regressions (available from the authors) document some evidence of price reversals. The coefficient of the previous-day excess return is significantly negative (at the 5% level) in the October 22, 1987 regression. Apparently, there were some overreaction phenomena in the first days of the crash.

The overreaction of Israeli stocks during the crash demonstrates that even the established defensive mechanisms of the Tel Aviv Stock Exchange (an "open" period before trade for receipt of offsetting orders, and a system of circuit breakers) were not enough to prevent panic effects. The next section examines the issue of circuit breakers' effectiveness in more detail.

IV. Evidence on Circuit Breakers

A. Can Circuit Breakers Dampen Panic Order Imbalances?

Panel A of Table III reports the mean relative order imbalances of Israeli stocks on October 20 and 21, 1987. Three different groups of stocks are compared: stocks that did not trade (had trade halts) on crash day; stocks that traded in the crash day auction only; and Mishtanim stocks, which traded both in the auction and in the bilateral trading stage.

[Table III about here]

An interesting finding is that stocks that traded on October 20 (groups (B) and (C) in panel A) had a relatively low excess supply on October 21. On October 21, the average excess supply of Mishtanim stocks (group (C)) was 0.13 of their normal absolute order imbalance; the average excess supply of other stocks that traded on crash day (group (B)) was 0.36 of their normal absolute imbalance. Both these imbalances are insignificantly different from zero, suggesting that between October 20 and 21, 1987 there was no major new order imbalance accumulation.

If the net imbalance generated between October 20 and October 21, 1987 is approximately zero, then the -1.48 relative order imbalance of trade-halted stocks (group (A)) on October 21 acquires a special meaning. It represents the order imbalance that did not evaporate during the trade halt. It appears that more than half of the initial order imbalance on October 20 disappeared by the October 21 opening.[6]

The evidence of order imbalance narrowing in stocks that had trade halts does not necessarily imply that trade halts per-se dampen panic order imbalances. Part of the observed 57% decline in order imbalances is due to the limit down price movement on October 20, 1987. At the lower opening prices of October 21, there was naturally less excess supply.

We have estimated the excess supply narrowing that can be attributed to the limit down price movement by assessing the excess supply that can be "covered" on a regular day (outside the crash period) by a one percent price drop, and multiplying it by the limit-down return (for more details see Lauterbach and Ben-Zion (1992)). According to these calculations the price decline on crash day "triggered" a 32% shrinkage in order imbalance. The remaining 25% decline in order imbalance is unexplained and may indicate some ameliorating effect of trade halts per-se.

The problem with the above estimation procedure and inference is that crash-period parameters are likely to be different than regular-day parameters. Thus, it cannot be concluded with confidence that trade halts contributed significantly to the reduction in order imbalances.

B. Can Circuit Breakers Moderate Panic Price Swings?

To examine trade-halt effects on the crash period price swings, we construct three return windows. The first window includes the return on October 20 and 21. All but eight stocks that did not trade on October 20 managed to trade on October 21. Thus, by October 21 the first immediate reaction to the crash was complete. The second window, which includes the full crash period (October 20 through 25), is intended to represent the intermediate (initial plus aftershocks) reaction. Finally, the October 20 through 29 window seeks to measure the "long-term" persistent effect of the crash.

Panel A of Table IV presents results of regressions of immediate-, intermediate-, and overall-period returns on beta, size, pre-crash gain, MISH_DUM (a trading dummy flagging the Mishtanim stocks), and TRAD_DUM (a dummy variable flagging the non-Mishtanim stocks that traded on crash day). The coefficients of the Mishtanim trading dummy are significantly negative in two out of the three return windows. Apparently, Mishtanim stocks suffered a 5.1% excess decline in the immediate two-day window, and a 2.5% excess decline in the intermediate six-day window.

Simple comparisons of mean returns, summarized in panel B, support this conclusion. The Mishtanim group declined by 6.0% more than non-Mishtanim stocks in the immediate return period, and by 4.6% more than non-Mishtanim stocks in the intermediate period.

[Table IV about here]

The longer-term perspective is different, however. During the overall window Mishtanim and non-Mishtanim stock returns are indistinguishable. Panel B shows that in the overall period both groups lost 14.3% of their value, and panel A documents that in the long-term return regressions the Mishtanim trading dummy scored a statistically insignificant coefficient. Thus, the Mishtanim aberration seems to have evaporated within ten days.[7]

The results in Table IV are suggestive. Apparently, the stocks that traded more frequently and had larger supply pressures on the crash day (Mishtanim stocks) overreacted by about 5%; and it took about ten days for this initial overshooting to disappear.

What caused the apparent overreaction of Mishtanim stock prices? Perhaps a clue can be provided by adding the relative order imbalance on October 20, 1987 as an independent variable to the immediate-term (October 20 through 21) regression of Table IV. If the aberration of Mishtanim stocks was caused by their relatively large excess supply pressures, then the coefficient of the October 20 relative order imbalance should be significantly different from zero, and the coefficient of MISH_DUM should become insignificantly different from zero.

Fitting the above expanded model, it was found that the coefficient of the October 20 relative order imbalance is 0.0014 with a t-value of 0.3, and the coefficient of MISH_DUM is -0.049 with a t-statistic of -5.7. It thus appears that the Mishtanim stocks unique dip on the first days of the crash cannot be explained by their stronger supply pressures.

The second trading dummy examined in Table IV, TRAD_DUM, identifies the non-Mishtanim stocks that traded on crash day. It is difficult to draw conclusions based on this subsample because it includes stocks that were relatively "favorites" at the time. Panel A of Table III shows that the group of non-Mishtanim stocks which traded on crash-day experienced less

selling pressure to begin with, and panel B of Table IV shows this group overall crash decline to be the least severe.

Nevertheless, the pattern of reaction of non-Mishtanim stocks that traded on crash-day is instructive. The difference between the immediate two-day and the overall crash-period reactions of these stocks is less than 1%. Stocks traded via single daily auctions (non-Mishtanim stocks) appear to have overreacted less than the "continuously traded" Mishtanim stocks. This finding is consistent with Roll's (1988) observation that in panics continuous trading and sharper price declines coincide. Roll's pithy conclusion is that "perhaps haste made waste in October 1987 (1988, p. 33)."

V. Summary and Conclusions

Trading mechanisms on the Tel Aviv Stock Exchange allow investigation of the net effect of circuit breakers and direct examination of official order imbalance data.

The main finding of the order imbalance analysis is that on October 1987 sell pressures in Israel were concentrated in higher beta, larger company, and lower leverage stocks. This evidence is somewhat surprising because smaller firms and higher leverage stocks might be expected to be dumped first in times of crisis. Traders may have concluded that less solid stocks had a good chance of selling at an inferior price.

The examination of circuit breakers yielded two important results. First, trading halts and price limits had no impact on the overall decline, but merely smoothed return fluctuations in the neighborhood of the crash.[8] Second, there are some weak indications that the trade halt helped cut the supply gap. According to our estimates, the drop in excess supply of trade-halted stocks between October 20 and 21, 1987 cannot be fully explained by the price drop.

The optimal mix between a continuous-trade system and a circuit breaker system is mainly an investor service issue. Regulatory agencies looking for an optimal trading system should weigh the hedge against execution price surprises that circuit breakers provide versus the liquidity advantage of free trading. It is possible that a special crash-period trading system that organizes a limited number of auctions on crash day and requires all orders submitted to these auctions to be limit orders could satisfy most market participants and prove socially beneficial.

Appendix: Sources and Calculation Methods of the Empirical Variables

A.1. $Beta_i$ - Beta of the Stock

The beta of stock i is estimated by running a market model regression on daily returns in the period 6/1/1987 - 10/12/1987. The market index employed is the value-weighted index of all TASE stocks published daily by the Tel-Aviv Stock Exchange and the Israeli Central Bureau of Statistics.

A.2. $GAIN_i$ - Pre-Crash Gain of the Stock

$GAIN_i$ is measured as stock i's return in the period 1/1/1987 - 10/12/1987. Average pre-crash gain is 31.3%.

A.3. LEV_i - Financial Leverage of the Firm

LEV_i is defined as total debt divided by total equity (both in book value). Total debt and total equity figures come from Meitav Stock Guide 12/86 balance sheet information. Average leverage is 4.5.

A.4. $PROF_i$ - Profitability of the Firm

$PROF_i$ is defined as net profit divided by book value of total equity. Both net profit and total equity figures are as of 12/86 and are collected from Meitav Stock Guide. The average profitability of the sample firms is 7.1%.

A.5. $RIMBT_i$ - Relative Order Imbalance of the Stock

The TASE publishes daily the pre-trade order imbalance for each stock. (It is customary to report excesses in demand as positive numbers and excesses in supply as negative numbers.) From these data $RIMBT_i$ is estimated as

$$RIMBT_i = \frac{IMBT_i}{\sum_T |IMBT_i| \,/\, N_T} \quad , \qquad (A.1)$$

where $IMBT_i$ is the reported order imbalance of stock i on day T, and the denominator is the average absolute order imbalance of stock i during the

sample period (10/13/1987 to 10/28/1987). $RIMBT_i$ essentially standardizes the order imbalance on day T by the average absolute magnitude of order imbalance. Note that the sign of $RIMBT_i$ is determined by the sign of the order imbalance of stock i on day t. If stock i is in excess supply on day t $RIMBT_i$ is negative.

A.6. RT_i - Return of the Stock

RT_i, the return of stock i on day T, is calculated from daily quote sheets of the TASE as *ln* (closing price of stock i on day T / closing price of stock i on day T-1). Returns are adjusted for splits and dividends.

A.7. $SIZE_i$ - Firm Size

The size of firm i is measured as *ln* (total assets of firm i on 12/1986 in millions of U.S. dollars). Meitav Stock Guide is the source of the data. Average $SIZE_i$ is 3.2, indicating an average book value of total assets of $25 million approximately.

A.8. $UR(T-1)_i$ - Previous Day Excess Return

The previous day excess return of stock i is approximated by the residual of the cross-sectional regression of $R(T-1)_i$ on $BETA_i$ and $SIZE_i$, i.e.,

$$R(T-1)_i = \alpha_0 + \alpha_1 BETA_i + \alpha_2 SIZE_i + UR(T-1)_i \quad . \qquad (A.2)$$

The basic assumption is that beta and size determine the normal return of the stock, so the residual is the abnormal or "excess" return of the stock.

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FOOTNOTES

[1] Grossman (1989, p. 7) defines panic as a situation where a large fraction of equity holders try to reduce their equity exposure at the same time (after observing a fall in price).

[2] Offsetting orders arrive from three main sources: 1) exchange members trading on their own account; 2) exchange members acting as the public's brokers - the auction progress is transmitted "live" to subscribers of the "Kav Manhe" computer communication network, and many large investors who watch the auction submit orders in real time by calling the offices of an exchange member representative; and 3) limit orders - the TASE computer updates the auctioneer about relevant executionable limit orders every time the auctioneer changes the price.

[3] Because of time-zone differences, the TASE was closed when the NYSE opened on October 19, 1987. Thus, the main Israeli response to Black Monday occurred on October 20, 1987.

[4] The results in Table II are robust to exclusion of outliers. In addition, tests of multicolinearity and normality do not reveal any significant deviations from OLS assumptions.

[5] The purpose of the four "normal behavior" variables is to reduce residual variance, so that the effect of the main variable, previous-day excess return, can be monitored more clearly.

Of the four variables representing the normal cross-sectional variation of stock returns, two (beta and size) are customary in financial economics (see Banz (1981), for example). The third, pre-crash gain of the stock, is a less standard variable, which we include for its dual explanatory power. First, it proxies for the average return of each stock, which might be

useful if beta and size cannot capture all cross-sectional variation in expected returns. Second, it controls for the possibility that the crash was the bursting of a bubble (see Hardouvelis (1990), for example).

The fourth explanatory variable, pre-auction relative order imbalance, proxies for the information that arrived for each stock since the previous-day close. The coefficients of relative order imbalance are positive and highly significant in all sample days, indicating that better news typically leads to larger excess demand and higher price advances. The finding of positive coefficients of relative order imbalance in the return regressions can also be interpreted as evidence of price overreaction to supply or demand pressures. However, given the fact that the return order imbalance relation is strong for all sample days (both inside and outside the crash period), it seems preferable to consider relative order imbalance as a normal behavior variable.

[6] Panel B of Table III elaborates the mean order imbalance comparison by controlling for stock characteristics. A multiple regression of relative order imbalance on four independent variables was run. The independent variables included the three stock characteristics found significant in the Table II regressions (beta, size, and leverage), and a new variable - HALT_DUM. HALT_DUM is a dummy variable for the stocks that did not trade on crash-day even after a limit down movement (123 stocks).

The results of the regressions in panel B support the previous conclusions. In particular, the coefficient of HALT_DUM in the October 21 regression (-1.34) indicates that stocks that did not trade on October 20 had an "unexplained" excess supply on October 21 equal to about 1.34 times their average absolute order imbalance. If this excess supply is a reasonable estimate of the excess supply left over from October 20, then order imbalance diminished by about 60% between October 20 and 21.

[7] A potential problem with the comparisons in Table IV is that Mishtanim and non-Mishtanim stock return data are non-synchronous. Mishtanim stocks trade for longer hours; their October 20 through 21 return, for example, also includes the return on October 21 after non-Mishtanim stocks had closed.

Data about the extra-hours (bilateral trading stage) return of Mishtanim stocks are available in the Official Daily Quote Sheet. Analysis reveals that any distortion introduced by the non-synchronization problem is relatively small. The average Mishtanim stock return in the bilateral trading stage is -0.57%, 0.48%, -0.13%, and 0% on October 19, 21, 25, and 29, respectively.

[8] It is noteworthy that the smoothed prices generated by a circuit breaker process are not necessarily less efficient than unrestricted trade prices. If, during the crash, prices of freely traded stocks fluctuate around the full-information equilibrium prices (because of liquidity constraints and less intervention by rational agents), then smoothing the price path by means of trade halts and single auctions need not necessarily yield a more biased price trajectory.

Table I

Summary Description of the October 1987 Crash in Israel

Trading Date[a]	Value-Weighted Stock Market Return (in %)[b]	Total Volume (in $ Million)	Number of Stocks with Excess Demand[c] (as of market opening)	Number of Stocks with Excess Supply[c] (as of market opening)
Oct. 13	2.4	5.9	122	53
Oct. 18	0.2	11.2	84	97
Oct. 19	-2.2	26.4	25	156
Oct. 20	-8.5	51.9	2	185
Oct. 21	-5.7	20.3	30	154
Oct. 22	4.5	17.6	164	21
Oct. 25	-5.6	19.9	4	182
Oct. 26	-1.1	13.6	62	117
Oct. 27	1.7	14.5	110	63
Oct. 28	0.7	11.9	93	90

[a] The exchange was closed October 14 through 17 for a holiday and on October 23 and 24 (the weekend).

[b] Market return and total volume statistics are from the Official Quote Sheet of the Tel Aviv Stock Exchange.

[c] The number of stocks in the sample is 187, but not all opened for trade every day. (Trade halts because of major firm-specific information releases are also customary.) Hence, the sum of the excess demand and excess supply columns is less than 187.

Table II

Regressions of Order Imbalances on Firm and Stock Characteristics Around the October 1987 Crash in Israel

$$RIMBT_i = \alpha_0 + \alpha_1\, BETA_i + \alpha_2\, SIZE_i + \alpha_3\, LEV_i + \alpha_4\, PROF_i + \alpha_5\, GAIN_i + \alpha_6\, UR(T-1)_i + \epsilon_i^T$$ [a]

Trading Date	Coefficients (t – statistics in parentheses)[b]							Adj. R^2	Number of Observations[c]
	α_0	α_1	α_2	α_3	α_4	α_5	α_6		
Oct. 13	-.06	.31	-.024	.0033	-.0009	.078	-2.3		
	(-0.4)	(2.4)	(-1.1)	(0.9)	(-0.8)	(1.9)	(-1.2)	.04	169
Oct. 18	.17	-.21	.008	.0008	.0009	.056	-1.7		
	(1.0)	(-1.5)	(0.4)	(0.4)	(1.5)	(1.6)	(-1.3)	.00	169
Oct. 19	-.30	-.01	-.009	-.0004	.0002	.001	-2.9		
	(-2.2)	(-0.1)	(-0.5)	(-0.1)	(0.1)	(0.0)	(-2.3)	.00	172
Oct. 20	-1.03	-1.22	-.465	.0314	-.0045	.019	-4.0		
	(-3.7)	(-4.7)	(-8.2)	(4.4)	(-1.7)	(0.1)	(-1.4)	.38	177
Oct. 22[d,e]	.96	.17	-.015	.0032	.0006	-.059	-7.2		
	(4.1)	(0.8)	(-0.3)	(0.6)	(0.4)	(-0.9)	(-4.8)	.12	175
Oct. 25	-1.02	-.49	.143	-.0103	-.0025	.006	4.7		
	(-5.9)	(-3.2)	(3.8)	(-2.3)	(-1.7)	(0.1)	(2.6)	.12	178
Oct. 26	-.59	.35	.020	.0055	.0004	-.033	0.6		
	(-1.9)	(1.6)	(0.5)	(1.5)	(0.1)	(-0.4)	(0.3)	.00	165
Oct. 27	.04	.25	-.002	.0025	-.0005	.150	0.8		
	(0.1)	(1.3)	(-0.0)	(0.5)	(-0.3)	(1.9)	(0.4)	-.01	163
Oct. 28	.27	-.16	-.014	.0002	-.0008	.069	-2.8		
	(1.2)	(-0.9)	(-0.4)	(0.1)	(-0.8)	(1.5)	(-1.7)	-.01	165

[a] $RIMBT_i$ is the relative order imbalance of stock i on day T; $BETA_i$ is the beta of the stock; $SIZE_i$, LEV_i and $PROF_i$ are measures of firm i's size, financial leverage and profitability; $GAIN_i$ is the return of stock i from 12/31/86 to 10/12/87, and $UR(T-1)_i$ is the previous day "excess" return on the stock. More details on the variables are provided in the Appendix.

[b] Standard errors are corrected for heteroscedasticity using White's (1980) method.

[c] The number of observations is less than 187 (the number of firms in the sample) because of exclusion of: 1) stocks that did not open for trading on that date because of major firm-specific news releases; 2) stocks that did not trade on the previous trading date; and 3) two firms for which the $PROF_i$ information is meaningless. (These two firms had negative equity in their 1986 balance sheets.)

[d] October 21 is omitted because of the potentially distorted sample on that date. About two-thirds of the stocks did not trade on October 20; hence the October 21 order imbalances are contaminated, in most of the stocks, by the October 20 imbalances. A detailed analysis of the October 21 behavior is provided in Table III.

[e] In the October 22 regression, $UR(T-1)_i$ is the excess return on the stock in the two-day interval 10/20–10/21,1987.

Table III

The Effect of Circuit Breakers on Order Imbalances During the October 1987 Crash in Israel

A Comparison of the Order Imbalances of Stocks That Did Not Trade, Stocks That Traded Frequently, and Stocks That Traded Lightly on Crash Day

Panel A: Comparisons of Mean Relative Order Imbalances

	Subsample	Mean Relative Order Imbalance On (Number of Observations in Parentheses)		t-statistic of Difference[a]
		October 20	October 21	
(A)	Stocks that did not trade on crash day even after a limit-down movement	-3.46 (123)	-1.48 (122)	-15.1
(B)	Stocks that traded in the crash day auction[b]	-2.64 (39)	-0.36 (38)	-7.3
(C)	Mishtanim stocks[c]	-5.24 (25)	-0.13 (25)	-25.6
	t-statistics of (A)–(C)[a]	9.4	-9.3	
	t-statistics of (A)–(B)[a]	-3.3	-4.9	
	t-statistics of (B)–(C)[a]	9.3	-1.0	

Table III (Cont.)

Panel B: Regression Results

$$RIMBT_i = k_0 + k_1\, BETA_i + k_2\, SIZE_i + k_3\, LEV_i + k_4\, HALT\_DUM_i + \eta_i^T$$ [d]

Trading Date	Coefficients of (t-statistics in parentheses)[e]				Adj.	Number of
	BETA	SIZE	LEV	*HALT_DUM*	R^2	Observations
October 20[f]	-1.22	-.482	.0334	-.18	.38	187
	(-5.1)	(-7.9)	(4.4)	(-0.9)		
October 21[g]	0.75	-.095	.0043	-1.34	.28	185
	(3.4)	(-1.3)	(0.4)	(-6.9)		

[a] t-statistics are calculated as $\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$ where $\bar{X}_1$, S_1^2 and N_1 are the mean, variance and number of observations in sample 1.

[b] Not including Mishtanim stocks.

[c] Mishtanim stocks include a select group of stocks that trade longer hours and more frequently. (See Section II.B for more details.)

[d] $RIMBT_i$ is the relative order imbalance of stock i on day T; $BETA_i$ is the beta of the stock; $SIZE_i$ and LEV_i are measures of firm i's size and financial leverage; and $HALT\_DUM_i$ is a trading dummy. $HALT\_DUM$ equals 1 for all stocks that had trade halts on crash day and equals 0 otherwise.

[e] Standard errors are corrected for heteroscedasticity using White's (1980) method.

[f] The regression coefficients and t-scores remain almost identical upon omission of stocks that did not trade on October 19, 1987.

[g] The number of observations on October 21 is less than 187 (the number of firms in the sample) because of two stocks that released major news and did not open for trading on that date.

Table IV

The Effect of Circuit Breakers on Stock Returns During the October 1987 Crash in Israel:

A Comparison of the Returns of Stocks That Did Not Trade, Stocks That Traded Frequently and Stocks That Traded Lightly on Crash Day

Panel A: Regression Results

$$RT_{1,}T_{2,} = K_0 + K_1 BETA_I + K_2 SIZE_i + K_3 GAIN_i + K_4 TRAD\_DUM_i + K_5 MISH\_DUM_i + \xi_i$$ [a]

Trading Interval	Coefficients of (t-statistics in parentheses)[b]		Adj.	Number of
	TRAD_DUM	*MISH_DUM*	R^2	Observations[c]
Oct. 20–Oct. 21	.015	-.051	.14	187
	(1.4)	(-7.0)		
Oct. 20–Oct. 25	.022	-.025	.13	187
	(1.7)	(-2.7)		
Oct. 20–Oct. 29	.037	-.011	.02	187
	(1.7)	(-0.6)		

Table IV (Cont.)

Panel B: Mean Return Comparisons

Subsample	Mean Return in the Interval			
	10/20–10/21	10/20–10/25	10/20–10/29	Observations
Mishtanim stocks	-18.5%	-19.2%	-14.3%	25
Non-Mishtanim stocks	-12.5%	-14.6%	-14.3%	162
t-statistic of difference[d]	-10.6	-6.3	0.0	
Non-Mishtanim stocks that did not trade on crash day even after a limit-down movement	-12.9%	-15.2%	-15.0%	123
Non-Mishtanim stocks that traded in the crash day auction	-11.3%	-12.4%	-12.0%	39
t-statistic of difference[d]	-1.4	-2.1	-1.5	

[a] RT_1T_2, is the cumulative return of stock i in days T_1 through T_2; $BETA_i$ is the beta of the stock; $SIZE_i$ is a measure of firm i's size; $GAIN_i$ is the return of stock i from 12/31/86 to 10/12/87, and $TRAD\_DUM_i$ and $MISH\_DUM_i$ are trading dummies. $MISH\_DUM$ equals 1 for all stocks that had more than one trading round on the crash day (Mishtanim stocks), and equals 0 for all other stocks. $TRAD\_DUM$ equals 1 for all stocks that had exactly one trading round on crash day, and equals zero otherwise.

[b] Standard errors are corrected for heteroscedasticity using White's (1980) method.

[c] When stocks that did not trade on October 19, 21, 25, or 29 are excluded from the corresponding regressions, the coefficients and t-scores of $MISH\_DUM$ remain almost the same, while the coefficients of $TRAD\_DUM$ increase by 0.01 on average and become statistically significant (t-values of 2.2–2.4).

[d] t-statistics are calculated as $\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$ where $\bar{X}_1$, S_1^2 and N_1 are the mean, variance and number of observations in sample 1.

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