Another Day, Another Collar: An Evaluation of the Effects of NYSE Rule 80A on Trading Costs and Intermarket Arbitrage

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ABSTRACT

In 1990, the NYSE amended its Rule 80A to restrict stock index arbitrage on days of large price movements. We design empirical tests to evaluate the impact of Rule 80A on trading costs and intermarket arbitrage. We find that Rule 80A significantly curtails--or "collars"-- index arbitrage activity. Despite the significant curtailment of index arbitrage activity, the cash and futures markets remain linked. Pricing discrepancies between the markets are simply eliminated less quickly. Our results are consistent with the hypothesis that information is conveyed from one market to the other by means other than formal arbitrage. We also find that trading costs in the stock market, as measured by the average bid-ask spread for S&P 500 stocks, do not change following the triggering of Rule 80A, in spite of the binding constraint on index arbitrage volume. Overall, Rule 80A appears to have had little impact on trading costs and intermarket arbitrage despite significant curtailment of index arbitrage volume.

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Section 1. Introduction.

Since the advent of stock index futures in 1982, stock index arbitrage has been a controversial trading practice because of its alleged role in contributing to stock market volatility. Episodes of extreme market volatility in 1987 and 1989 heightened the controversy, leading many policymakers and market professionals to request that the New York Stock Exchange (NYSE) take steps to restrict the practice.[1/] In response to these requests, the NYSE amended its Rule 80A in July 1990 to restrict--or "collar"-- stock index arbitrage on days of large price movements. These restrictions were implemented for a one-year trial period and became permanent in 1991 after formal approval by the United States Securities and Exchange Commission.

Since the rule's adoption, its restrictions have been triggered, on average, more than twice per month. Here is how it works: On days when the Dow Jones Industrial Average ("Dow") declines by 50 points or more from the previous day's closing value, Rule 80A requires all index arbitrage sell orders for stocks from the Standard and Poor's 500 Index ("S&P 500") to be entered with the instruction "sell plus."[2/] Conversely, on days when the Dow advances by 50 points or more

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[1/] See The Report of the Presidential Task Force on Market Mechanisms, January, 1988; and Trading Analysis of October 13 and 16, 1989, Division of Market Regulation, U.S. Securities and Exchange Commission, May 1990.

[2/] "Sell-plus" means that the order can be executed on a plus or zero-plus tick. A plus tick is a price above the price of the preceding sale. A zero-plus tick is a price equal to the preceding sale if the last transaction at a different price was at a lower price. "Buy-minus" means that the order can be executed on a minus or zero-minus tick. A minus tick is a price below the price of the preceding sale. A zero-minus tick is a price equal to the preceding sale if the last transaction at a

(continued...)

from the previous day's closing value, the rule requires all index arbitrage buy orders for stocks from the S&P 500 to be entered with the instruction "buy minus." The tick restrictions apply to all index arbitrage orders in component S&P 500 stocks traded at the NYSE, regardless of how the orders are routed to the specialist's post.[3/] The tick restrictions are removed at the end of the trading day, or sooner if the market rebounds to a level within 25 Dow points of the previous day's close.

Like the practice it was designed to curtail, Rule 80A has generated considerable controversy. This controversy has featured many *ad hoc* assertions about the rule's alleged effects--assertions that do not necessarily follow from any simple model of market microstructure. Rather than addressing every claim that has been made in the public policy debate concerning the rule, we focus our attention on claims that can be translated into testable propositions readily delivered by models found in the literature on market microstructure. We empirically test propositions concerning the effect of Rule 80A on: 1) the linkage of the stock market and the futures market; and 2) trading costs in the stock market. Focusing our attention on testable propositions means that we choose not to consider other assertions, such as the one frequently made in the financial press that Rule 80A has prevented market crashes, since such assertions cannot be restated as refutable hypotheses derived from any recognized microstructure model. We consider market volatility, a variable of particular interest in the public policy debate, to be one component of the aforementioned trading costs.

In constructing our tests, we compare market behavior before and after the triggering of the

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[2/] (...continued)
different price was at a higher price.

[3/] Exempt from Rule 80A are index arbitrage program trades for market-on-close orders for index options or index futures expirations.

rule's tick restrictions. To isolate changes attributable to Rule 80A, we compare market behavior on days when the rule was triggered to its behavior on days before the rule's adoption when Rule 80A would have been triggered had it been in place.

Our findings can be summarized as follows. When Rule 80A is triggered:

1. **Index arbitrage volume falls significantly.** There is a significant decrease in the dollar volume of index arbitrage associated with the S&P 500 futures contract on the Chicago Mercantile Exchange (CME). Sell-side and buy-side arbitrage is less than a third of what would be expected relative to the control period. Agency arbitrage is more severely constrained than principal index arbitrage. Sell-side and buy-side agency index arbitrage associated with the S&P 500 futures contract is less than 7 percent of what would be expected relative to the control period.

2. **The cash and futures markets remain linked.** Despite the sizable reduction in index arbitrage activity when Rule 80A is in force, the markets remain linked. Pricing discrepancies between the markets are simply eliminated less quickly than when index arbitrage is not constrained.

3. **Trading costs are not materially affected.** Trading costs in the stock market, as measured by bid-ask spreads, do not fall in spite of the binding constraint on index arbitrage volume. Relative to the control group, both total trading volume (inversely related to the spread) and short-term volatility (directly related to the spread) decline after Rule 80A is triggered. The overall impact of these opposing forces on bid-ask spreads is ambiguous.

These findings complement the evidence in three other studies of Rule 80A. The *NYSE Report* (1991), completed at the request of the SEC, evaluates the performance of Rule 80A in the nine months following its adoption. The NYSE's main conclusion, that the rule produced little overall effect on the stock market, is consistent with our own findings despite differences in control periods, sample periods, and statistical measures. Kuserk, Locke, and Sayers (1992) evaluate the impact of Rule 80A on the S&P 500 futures market in the three months following the rule's adoption. These authors conclude that "80A does not appear to be unduly constraining index arbitrage" and that "no harm to the (futures) market making sector is found." To obtain their

conclusions, they compared the S&P 500 cash-futures basis on days when the tick restrictions were with that basis during a control period when the tick restrictions were not in effect. Our conclusions differ from the conclusions of these authors in that we find Rule 80A to significantly constrain index arbitrage activity. We attribute the different findings to the different measures of index arbitrage volume. We are able to observe index arbitrage volume directly whereas Kuserk *et al*. infer arbitrage volume by observing basis behavior.

Like the NYSE report and Kuserk *et al.*, Santoni and Liu (1993) look at the impact of the rule in the months immediately following the rule's adoption. They find that intraday stock market volatility (measured as unconditional variance of percentage price changes over one-minute intervals) falls after the rule is triggered, whereas volatility increases around similar market moves in their control sample. Our findings with respect to market volatility, which are included as part of our analysis of trading costs, are consistent with this result.

In this paper we construct more powerful tests than those used in the three previous studies. We examine a larger set of observations over a three-and-a-half year period. We also employ a broader control group than in the previous studies. Finally, we segment our test and control samples to account for known time-of-day effects in the prices of stocks and futures.[4/] Our tests are based on a detailed minute-by-minute (and in some cases trade-by-trade) analysis of 39 midday events where Rule 80A was triggered. We find that our conclusions are not sensitive to variations in our control group--even when we include observations from the days surrounding the 1987 market crash.

[4/] For discussion of time of day effects see Amihud and Mendelson (1987), Ekman (1992), Gerety and Mulherin (1992), Harris (1986), Jain and Joh (1988), and Stoll and Whaley (1990).

Section 2. Theory and Testable Propositions.

2.1 Index Arbitrage and Market Linkage

We use the term "market linkage" to describe the degree to which prices in one financial market reflect information contained in prices from related financial markets. Markets are linked in part by the order flow generated by arbitrage trading. Miller (1992) has referred to this order flow which serves to inform market makers about intermarket price discrepancies as "formal" arbitrage to distinguish it from other market-linking mechanisms, such as good shopping by knowledgeable investors, that do not involve arbitrage-generated order flow.

One issue appearing in the recent microstructure literature is the role that formal arbitrage plays in linking markets. In one set of models, the market-linking role of formal index arbitrage is critically important. For example, in Kumar and Seppi (1994), who extend the model of Kyle (1984,1985) to include the specifics of index arbitrage, market-makers observe the net order flow only in their own market and set prices conditional on that information. A testable proposition from this type of model is that the arbitrage-curtailing effects of Rule 80A will impair the linkage of the futures and the cash market.

In another set of models, the order flow generated by index arbitrage is not critical to the linking of markets. An example of this type of model is that of Chowdry and Nanda (1991), who extend the Kyle model to allow market makers to observe price information from markets other than their own. In this type of model, a market-maker observing a sudden jump in the futures price does not wait around for arbitrage order flow to arrive. The mere threat of arbitrage (e.g., after Rule 80A expires) causes the market maker to revise his quotes, thus keeping markets linked without any

formal arbitrage taking place. A testable proposition from this type of model is that Rule 80A will not impair the linkage between the futures market and the stock market.

The same testable proposition emerges from Miller (1992) and Miller, Muthuswamy, and Whaley (1994), who have suggested another reason why formal arbitrage may not be necessary to keep markets linked. According to this argument, investors use one of two methods to adjust the exposure of their portfolios--either effecting a single transaction in the futures markets or replicating the index through multiple transactions in the cash market. Investors will choose the cheaper of the two routes, taking into account not just the direct transaction costs but also any mispricing of the futures market relative to its theoretically correct value as implied by the cost-of-carry relationship between futures and cash prices. In short, according to this argument, good shopping by knowledgeable investors keeps the markets linked without any formal arbitrage.

2.2 Index Arbitrage and Trading Costs

One of the most controversial aspects of index arbitrage is its effect on the cost of market-making. In the microstructure literature, index arbitrage can affect the cost of market-making in two ways. The first is purely institutional, resulting from differences between CME and NYSE rules concerning price continuity. Specialists lose to index arbitragers by providing price continuity whenever market moves are discontinuous. The arbitrager gains at the specialist's expense by selling stock to the specialist that both know is overvalued or buying stock from the specialist that both know is undervalued.

Second, index arbitragers may have an informational advantage that creates an adverse selection cost for the relatively less-informed market-makers. This cost can be seen most clearly

in the case of those who enter limit orders on the specialist's book. These market-makers commit themselves to trade a stipulated number of shares at prices announced in advance. Arbitragers can pick off obsolete resting limit orders before they are adjusted to reflect new information being signaled by the futures market. If the volume of index arbitrage increases, the losses to writers of limit orders will also increase. Miller (1992) has compared the costs that index arbitrage imposes on market-makers to an excise tax on market liquidity that is collected by the arbitrager instead of the government.

Kumar and Seppi (1994) explicitly model the effects of this type of informational advantage. In their model, arbitragers observe the imperfectly correlated evolution of the various market-makers' beliefs across different markets. Since market-makers in this model observe only information contained in the order flow of their own market, their information lags behind that of the arbitrager who sees information contained in the prices of other markets. A testable proposition resulting from this model of market microstructure is that the trading costs of market-makers should be lower when index arbitrage is curtailed, such as under Rule 80A, than they would be when index arbitrage is not restricted.

2.2.1 Index Arbitrage and Market Volatility

The market microstructure literature identifies short-term price volatility as an important component of the bid-ask spread (see, for example, Stoll, 1989). Short-term volatility--to the extent it is affected by index arbitrage order flow--serves as a potential transmission mechanism between index arbitrage and trading costs as measured by the bid-ask spread. The effect of index arbitrage on price volatility has been studied by Cuny and Stoughton (1992), who demonstrate that even when

arbitragers have superior information about intermarket price discrepancies, the volatility of price changes over time should be unaffected by index arbitrage. Empirical work consistent with this view can be found in Harris *et al.* (1990). The results of these studies yield an additional testable proposition concerning Rule 80A and trading costs: the volatility component of the bid-ask spread should be unaffected by the triggering of Rule 80A.

Section 3. Data and Summary Statistics.

3.1 Days in the Sample.

Although Rule 80A is triggered by changes in the Dow, our analysis focuses on changes in the S&P 500 because it is this index's component stocks that are affected by the rule's tick restrictions. The S&P 500 index is not calibrated with the Dow, so 50 Dow points correspond to a range, rather than a specific number, of S&P 500 index points. In our sample the S&P 500 cash index had moved anywhere from 3.43 to 8.62 points from its previous close before Rule 80A was triggered.

Panel A of table 1 lists our test sample of 39 midday events when Rule 80A was triggered from August 1990 through December 1993.[5/] Table 1 also indicates the time that the trigger was hit and the total price change (from the previous day's close) in the S&P 500 futures contract and cash index at that time. Panel B of table 1 identifies the 27 control days used in our tests. The controls occurred on a set of days from October 1986 through July 1990 when the Dow moved 50 points from its previous close. These days would have triggered Rule 80A had it been in place at

[5/] Rule 80A was triggered an additional 39 times during the market open or close or on days in which the CME trading limits, or "circuit breakers," were in effect. We define the first half hour of trading as the open, the last half hour as the close, and the intervening period as the midday.

the time.[6/]

Table 1 Here.

To obtain a clean test of Rule 80A, the samples shown in table 1 have been culled from a larger set of initial observations using the following selection criteria. First, events during 1988 were excluded from the control sample because the collar on the NYSE's Designated Order Turnaround system (DOT) was in effect at that time. Second, we exclude events within 30 minutes of the open or the close.[7/] Third, we exclude days when "circuit breakers" on the S&P 500 futures contract of the CME were triggered. The CME has had circuit breakers in place for its S&P 500 futures contract since October 1988.[8/]

During our test period, Rule 80A was triggered on 68 occasions on 67 days.[9/] From our initial sample of 68 events, we use as the basis of our tests 39 instances in which Rule 80A was

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[6/] Since the Dow was lower during the control period, 50 Dow points would be a larger percentage swing in the control period than in the test period. However, the rule has stayed with 50 points since its initial implementation and we believe that specifying point changes rather than percentage changes is consistent with how the rule would have been administered had it been in place during our control period.

[7/] In using midday observations we conform to the suggestion of Miller (1990) who argues that the real test of Rule 80A is when it is triggered in the middle of the day. We confine our attention to midday observations because including opening or closing events would yield insufficient observations to perform meaningful "before" versus "after" comparisons, that is, the event window would be significantly truncated on one side or the other. In addition, observations from the market open are potentially corrupted by delayed openings for stocks.

[8/] Table 1 indicates that the futures contract could be close to its CME trading limit, or "circuit breaker," before the cash market triggered Rule 80A. The CME circuit breaker is triggered by a 12-point movement in the nearby S&P 500 futures contract. Indeed, the CME circuit breaker was triggered before Rule 80A on August 6, 1990. A ninety minute window around the time when Rule 80A was triggered includes almost all of these circuit breaker events. Changes in the behavior of cash or futures markets may be due to the circuit breaker or the anticipation of those circuit breakers.

[9/] Rule 80A was triggered twice on August 21, 1990.

triggered in the midday, that is, after the first half hour of trading and before the last half hour.

3.2 Prices, Volume, and Bid-Ask Spreads.

Price and volume data come from several sources. Tick Data, Inc., provides tick-by-tick price data for the S&P 500 futures contract using the official time and sales record of the CME. They also provide data on the S&P 500 cash index and the Dow sampled at frequent, but irregular, intervals of less than one minute. We calculate bid-ask spreads and trading volume for the S&P 500 cash index from the Securities Industry Automation Corporation records. We identify index arbitrage transactions from NYSE records.

For the purposes of this study, we measure index arbitrage as the dollar value of all NYSE stock transactions directly corresponding with the establishment or liquidation of S&P 500 futures positions as recorded in the NYSE's program trading reports. These records distinguish between trades that are for principal accounts (trades for the member firm's own account) and trades for agency accounts (trades for a member firm's customer accounts). We record index arbitrage volume in one-minute intervals for 90 minutes before and after the triggering of Rule 80A.[10/] We measure aggregate trading volume as the aggregate dollar value of all transactions in S&P 500 stocks listed on the NYSE. These data are recorded in one-minute intervals for 90 minutes before and after the triggering of Rule 80A. Daily dividends on the S&P 500 index are recorded from various issues of the *S&P 500 Information Bulletin*.

[10/] The event window is truncated for events that occur within 90 minutes of the open or the close. For example, an event occurring at 10:30 a.m. would have only 60 one-minute intervals in the "before" sample. All sample windows have at least 30 one-minute intervals observed on each side of the event trigger.

3.3 Event Time Plots.

Charts 1 and 2 display S&P 500 cash and futures price indexes respectively, recorded in event time, for the 180 minutes surrounding the triggering of Rule 80A. We use these series in our statistical tests. The index for each day is standardized to equal 100.0 when Rule 80A is triggered in the test group or would have been triggered in the control group (that is, t=0). Both the test and control samples are separated into up and down samples (which consist of days for which Rule 80A restricted arbitrage buy and sell orders respectively). The daily index values are then aggregated into an equally weighted index for the sample.

Charts 1 and 2 Here

Both charts show a close correspondence between the test and control samples. There appear to be no significant differences in the pattern of cash returns between the control and test samples within 30 minutes of the event. Over the 90- minute interval, the increases or decreases are about .83 percent for all groups. The indexes continue down or up briefly after the 50 point move, possibly because of the normal autocorrelation present in the index.[11/] The indexes are basically flat afterwards, however, as one would expect in efficient markets without a trend. Furthermore, these returns are insignificantly different from zero over this 90-minute window.

[11/] The autocorrelation may be due to stale prices. The last reported trade for some securities in the index may have occurred several minutes earlier. Such prices would not be currently available for arbitragers. In contrast, the futures price has no stale elements. As a result, the futures price will tend to lead the cash price when market prices trend in one direction or another. See Harris (1986) and Miller, Muthuswamy, and Whaley (1994).

Section 4. Tests.

4.1 Index Arbitrage Volume.

If Rule 80A's tick restrictions increase the cost of completing the cash leg of an index arbitrage trade, index arbitrage trading volume should decline. Table 2 displays summary statistics for "restricted" index arbitrage volume, that is, index arbitrage programs subject to the tick restrictions of Rule 80A, and t-statistics for testing the equality of mean values between the test and control groups. The statistics are calculated separately for 50-point decreases (panel A) and increases (panel B) in the Dow. The first row of each panel of the table reports index arbitrage trading volume subject to Rule 80A's restrictions (i.e., S&P 500 stock purchases when zero-down-tick restrictions are imposed and S&P 500 stock sales when zero-up-tick restrictions are imposed), aggregated separately for the 90 minutes before and the 90 minutes after the triggering of Rule 80A. Positive values reflect purchases of S&P 500 component stocks and negative values reflect sales. These figures are reported as averages over the number of Rule 80A events in each category.

Table 2 Here.

Total restricted arbitrage, reported in the first row of each panel, is partitioned by account type in rows two and three. The second row of each panel displays restricted principal index arbitrage volume, that is, index arbitrage conducted by an NYSE member firm for its own account. The third row of each panel displays restricted agency index arbitrage, that is, index arbitrage

conducted for a member firm's customer account.

The observations displayed in table 2 are consistent with the hypothesis that Rule 80A is a binding constraint on index arbitrage volume. Restricted index arbitrage volume (i.e., volume for the test group) in the 90 minutes after a 50-point move in the Dow is lower than in the 90 minutes before both in absolute terms and relative to index arbitrage volume in the control group. Panel A shows that in the control group S&P 500 index arbitrage sell volume increased from about $100 million in the 90 minutes before a 50-point move in the Dow to $130 million in the 90 minutes following. In the test group, restricted index arbitrage sell volume decreased from $124 million before to $45 million after. This means that on down days, restricted index arbitrage volume after the trigger was only 28 percent of what would be expected given the control period.

Panel B of table 2 shows that on up days, restricted index arbitrage fell from $162 million to $44 million in the test period but only fell from $133 million to $127 million in the control period. This means that on up days, restricted index arbitrage volume after the trigger was only 28 percent of what we would have expected given the control period.

Both panels in table 2 tell the same story about the impact of Rule 80A index arbitrage volume. Before 50 point Dow moves there is no statistically significant difference between mean index arbitrage volume in the test and control groups. After 50 point Dow moves, mean volume in the test group drops significantly relative to the control group. This observation is consistent with the hypothesis that Rule 80A is a binding constraint on index arbitrage activity.

These observations are not consistent with the findings of Kuserk *et al.* (1992), who conclude that "80A does not appear to be unduly constraining index arbitrage." We attribute the different findings to the different measures of index arbitrage volume. We are able to observe index

arbitrage volume directly whereas Kuserk *et al.* infer arbitrage volume by observing basis behavior.

Both principal and agency index arbitrage volume decline after Rule 80A is triggered, although the biggest impact is on agency volume. In the 90 minutes after the triggering of Rule 80A, principal index arbitrage volume declines relative to the volume observed in the 90 minutes before the triggering of the rule, both on down days and up days. These observations are reported in the second row of panels A and B of table 2. On down days, principal index arbitrage volume declines to 44 percent of what was observed before the trigger, a decline from $98 million to $43 million. On up days, principal index arbitrage volume declines to 33 percent of what was observed before the trigger, a decline from $127 million to $42 million. In the control period, principal index arbitrage was virtually unchanged surrounding 50-point moves.

Agency index arbitrage volume is almost entirely eliminated when Rule 80A is triggered, both on up days and down days, and the decrease in volume is statistically significant (see the third row of panels A and B of table 2). On down days, agency index arbitrage volume falls from an average of $25 million to $2 million around the triggering of Rule 80A--a 93 percent decline in dollar volume. This decline is striking when compared with the increase (from $34 million to $63 million) in agency index arbitrage during the control period around 50-point decreases in the Dow.

On up days, agency index arbitrage volume falls from $35 million to $600,000 around the triggering of Rule 80A's restrictions, a 98 percent decline in dollar volume. This decline in volume is striking when compared with the control period's modest decline (from $81 million to $77 million) around 50-point increases in the Dow.

The differing effects of Rule 80A on agency and principal index arbitrage volume may be due to NYSE regulations that pre-dated Rule 80A. For example, the NYSE's short-sale tick

restriction (which pre-dates Rule 80A) is more likely to affect a large NYSE member firm than its customer-- independent of any Rule 80A tick restrictions, because an NYSE member firm is more likely than its customer to be a far-flung operation with many trading desks. Given that it is costly to monitor compliance with the NYSE's short-sale restrictions across all trading desks at all times, these firms may have voluntarily submitted tick-sensitive orders to avoid violating short-sale restrictions even before the adoption of Rule 80A. Sofianos (1993) presents evidence of such behavior by some traders.

4.2 Testable Propositions Concerning the Effects of Rule 80A on Market Linkage.

Since the testable propositions concerning market linkage and index arbitrage discussed in the previous section need to be made operational, we model the stochastic process linking cash and futures prices as an error-correction mechanism. The intuition behind this specification is that the persistence of basis error is a sign that markets are not closely linked. Our error-correction specification for the S&P 500 is

$$\Delta cash_t = g(be_{t-1} - c) + a(L)\Delta future_t + b(L)\Delta cash_t + \varepsilon_t \qquad \textbf{(1)}$$

where the variable "cash" is the logarithm of the cash price index, "future" is the logarithm of the futures price, and "be" is the logarithm of the basis error that itself is defined here as the futures price divided by the fair value futures price. The constant term, "c," shows whether the basis error differs from zero. The coefficient "g" produces an estimate of the adjustment speed of the cash index to lagged basis error. It is this coefficient that we are most concerned about in generating an operational hypothesis to be tested. If the adjustment speed coefficient falls significantly after Rule

80A is triggered, then it can be argued that market linkage is impaired, i.e., that basis error persists for a longer time. The lagged futures and cash price changes, measured here by the polynomials a(L) and b(L), capture other dynamic factors in pricing. The operational null and alternative hypotheses can be restated as:

$$H_o: g_{before} = g_{after}$$

$$H_A: g_{before} \neq g_{after}$$

To test whether Rule 80A affects market linkage, the sample for each event is split into pre-50-point samples (t=-90,...,-1) and post-50-point samples (t=0,...,+90) for both the test and control groups. Five lags are used on the cash and futures prices. Equation (1) is estimated for each day containing sufficient observations in each sample to identify all coefficients.

We summarize the evidence on market linkage and the persistence of basis error in table 3. The table lists the average estimated adjustment-speed coefficient (g), its average t-statistic, and the number of events with significant adjustment-speed coefficients for the pre-event and post-event samples. Finally, the table includes the F-statistic to test for structural stability in the entire equation surrounding 50-point Dow moves. For conciseness, the coefficients for a(L) and b(L) are omitted from the table.

Table 3 Here.

Comparison of the estimated g coefficients reveals that the average estimated adjustment-speed coefficient changes quantitatively in the test sample, but not in the control sample. For the sample of all test events, the average 'g' coefficient drops from .131 to .073, indicating that price

discrepancies between the two markets are corrected less quickly after Rule 80A is triggered. In contrast, for the sample of all control events, the average 'g' coefficient changes insignificantly from .109 to .104. Similar results are reported for up moves and down moves when tested separately. This evidence suggests that Rule 80A weakens the linkage between the markets, in that adjustment toward equilibrium is slowed (i.e., basis error persists longer), but that the linkage is not broken.[12/] Our result--that market linkage is not broken but that the speed of adjustment is slower and that basis error persists longer than when formal index arbitrage is not constrained--is consistent with the "smart shopping" hypothesis of Miller (1992) and Miller, Muthuswamy, and Whaley (1994).

The F-statistics lead us to reject stability (at the 5 percent level) in 19 of 39 test events but in only 6 of 27 control events. Thus, structural stability is rejected more frequently in the test sample than in the control sample. The average F-statistic, while 2.04 for the test sample, is only 1.36 for the control sample and is consistent with the hypothesis that Rule 80A affects the stochastic process linking basis error to cash prices.[13/]

4.3. Tests of the Effect of Rule 80A on Trading Costs.

4.3.1. Bid-Ask Spreads.

To run an operational test of the effect of Rule 80A on trading costs, we use the bid-ask

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[12/] An otherwise identical specification substitutes $\Delta future_t$ as the dependent variable. Then generalized least squares or an augmented vector auto regression can be used to estimate the two equations simultaneously to account for contemporaneous correlation of the error components in the two equations. We present only the cash equation estimates here. There is essentially no change in the estimates for the futures equation, either pre or post, control or test sample. Also, we conducted Granger causality tests for the futures and cash markets. Using five-minute lags on this sample, the estimates of causality were unchanged.

[13/] The critical value for the F-statistic at the five percent level of confidence is approximately 1.60 for these samples.

spreads quoted by marke-makers as our summary measure. As Stoll (1989) has shown, changes in the quoted bid-ask spread should reflect changes in trading costs. The operational null and alternative hypotheses can be restated as:

$$H_o: \text{B/A Spread}_{\text{before}} = \text{B/A Spread}_{\text{after}}$$

$$H_A: \text{B/A Spread}_{\text{before}} \neq \text{B/A Spread}_{\text{after}}$$

We compare bid-ask spreads in our test and control samples before and after 50 point Dow moves.[14/] We calculate minute-by-minute spreads for each firm as:

$$10{,}000 * \frac{(P^{ask} - P^{bid})}{[(P^{ask} + P^{bid})/2]}$$

We then form a "spread index" of S&P 500 firms by averaging the percentage bid-ask spreads across these firms, giving equal weight to each NYSE-listed firm in the S&P 500 index.

Table 4 displays the average bid-ask spreads surrounding 50-point Dow moves. For down days, the bid-ask spread increases both on days in the control sample and on days in the test sample. In the control sample, the percentage bid-ask spread goes from 82.36 basis points to 87.65 when the 50-point mark is breached. In the test group, the percentage bid-ask spread rises from 96.33 basis points to 100.27 after Rule 80A is triggered. In dollars, the average spread for the test group widens 4 cents per share on a stock worth $100 per share and that of the control group increases by 5 cents per share. In terms of tick size, in order for the average change in the bid-ask spread to be worth a sixteenth of a dollar, each share of stock would need to be worth approximately $160 at a time

[14/] Minute-by-minute bid-ask spread data were incomplete or could not be recovered for 19 of the 39 test events. Although the missing observations reduce the number of observations, the omissions are random and should not systematically affect our results.

when the average price of a NYSE share was approximately $34. Overall, on down days, the evidence from average bid-ask spreads shows that on days Rule 80A was triggered there was little change in spreads either in absolute terms or relative to the control group.

Table 4 Here.

For up days, table 4 shows that spreads increase from 73.95 basis points to 75.71 in the control group around 50-point Dow moves. In the test group, the average percentage bid-ask spread falls from 94.13 basis points to 93.27 as Rule 80A is triggered. In dollars, the average spread for the test group falls less than a penny per share on a $100 per share stock. In terms of tick size, in order for the average change in the bid-ask spread to be worth a sixteenth of a dollar, each share of stock would need to be worth approximately $700. Overall, on up days, the evidence shows that Rule 80A has had little effect on bid-ask spreads either in absolute terms or relative to the control group.

Summary statistics may not tell the entire story of specialist behavior when confronted with large moves in the Dow. Specialists adjust spreads to account for volatility and volume, and the percentage spread may reflect the index level if the minimum tick is binding on the absolute spread. To account for these factors, a multivariate regression analysis is employed. We use the average spread as the dependent variable in a cross-sectional regression. We define LEVEL to be the average cash index value in the 30 minutes before or after a 50-point event. We define VOLUME to be the average dollar volume of the S&P 500 stocks during the 30 minutes before or after the

event. The standard deviation of minute-by-minute index returns for the 30 minutes before and after the event is defined as SIGMA. To distinguish between observations generated by the test sample and those generated by the control sample, we define the dummy variable TEST to equal one if the observed spread is from the test sample and zero if it is from the control sample. To distinguish between observations before and after a 50-point Dow move, we define the dummy variable POST to be one if the spread is generated from the portion of the sample observed after the 50-point move, and zero if the spread is generated from the pre-50 point portion of the sample. Finally, we define the dummy variable POSTTEST to be one if the observation follows a 50-point Dow move and is in the test sample.

A semi-logarithmic specification is estimated. The point estimates for this equation (t-statistics in parentheses) are:

ln(SPREAD)=	11.25	- 1.21*ln*(LEVEL)	+.20*ln*(VOLUME)	+ .028(SIGMA)		
	(21.0)	(-12.7)	(0.6)	(2.8)		
		+ .297(TEST)	+ .019(POST)	- .008(POSTTEST)	R^2=.844	
		(9.8)	(0.6)	(-0.2)		

The dummy variable TEST is highly significant, indicating that bid-ask spreads are about 30 percent larger during the test period for reasons not explained in the regression. However, neither POST nor POSTTEST is significant. This insignificance indicates that spreads are no larger after the 50-point Dow move in both the control and test samples after controlling for the effects of volume, volatility, and index level. The coefficient for VOLUME is positive but insignificant indicating no independent effect on spreads. High volume is generally associated with small bid-ask spreads.

However, if this volume is largely unanticipated one-sided volume, the capacity of marketmakers can be strained and they may respond by widening their spreads.[15/] Overall, this evidence suggests that rule 80A has had little effect on how specialists set spreads.

4.3.2 Market Volatility.

Table 5 presents summary and test statistics used to compare volatility in periods before and after the triggering of Rule 80A. This comparison is done for both the test group and the control group. The table presents, for down days and up days respectively, the unconditional standard deviation of minute-by-minute returns (expressed in percentage basis points) from the S&P 500 cash index and the nearby S&P 500 futures contract. We use minute-by-minute observations to construct this test.

Table 5 Here.

The operational hypothesis and its alternative can be restated as:

$$\sigma_{before} = \sigma_{after}$$

$$\sigma_{before} \neq \sigma_{after}$$

The test results displayed in Table 5 show that before to the rule's adoption, that is, for the control group, cash index volatility increased after a 50-point Dow move. On down days volatility

[15/] We do not attempt to discriminate between inventory management and asymmetric information components of the bid-ask spread (Glosten and Harris 1988, and Stoll 1989). Nor do we consider the issue of quote revision (Hasbrouck 1988).

rose from 3.05 percentage basis points to 3.90, and on up days, volatility rose from 2.71 percentage basis points to 2.81. However after the rule's adoption, that is, for the test group, cash index volatility declined after a triggering move in the Dow. On down days, volatility decreased from 3.55 percentage basis points to 2.34. On up days, volatility decreased from 2.14 percentage basis points to 1.84. For the sample of down days, the observed differences in volatility before and after a triggering event is significant for both the control group and for the test group. These results are consistent with the intraday results reported by Santoni and Liu (1993).

In contrast, futures volatility increases slightly after triggering events following the adoption of the rule. On down days, volatility rose from 6.48 percentage basis points to 7.64. On up days, volatility rose from 4.30 percentage basis points to 4.63. These before and after changes are not statistically significant, however. Before and after changes in the futures control group are also statistically insignificant. Overall, the evidence presented in Table 5 is consistent with the hypothesis that while Rule 80A is associated with a reduction in cash market volatility, it does not affect futures market volatility.

The impact of Rule 80A on short-term cash market volatility can be summarized by normalizing the results of the test group with the results of the control group. Relative to the control group, the triggering of Rule 80A is associated with a significant decline in minute-by-minute cash market volatility. On down days, relative to the control group, minute-by-minute volatility declines by approximately 50 percent after the triggering of Rule 80A. On up days, the decline in volatility is nearly 20 percent relative to the control group.

This decrease in measured volatility is associated with a change in the autocorrelation process of the return series. Consistent with our determination that basis error persists longer when

Rule 80A is in effect, we find that cash return series displays greater positive autocorrelation after Rule 80A is triggered. For both test groups, a typical series of returns displays first-order autocorrelation before the triggering of the rule, but displays first- and second- order autocorrelation after the rule is triggered. The more positively autocorrelated series translates into a less volatile return series.

A decrease in market volatility, all else being equal, should result in a reduction in trading costs as measured by bid-ask spreads. However, all else does not remain equal. Overall S&P 500 trading volume declines significantly following the triggering of Rule 80A. Relative to the control group (in which trading volume was largely unaffected by the breaching of the 50-point threshold), trading volume of all types declines by nearly 30 percent on down days and 7 percent on up days. The result is that, relative to the control group, both total trading volume (inversely related to the spread) and short-term volatility (directly related to the spread) decline after Rule 80A is triggered. The overall impact of these opposing forces on bid-ask spreads is inconclusive.

Our measure of the volatility component of the bid-ask may mask the true level of volatility as perceived by the specialist. The observed minute-by-minute price adjustment process may indeed be slower and smoother as the volume of one-sided index arbitrage order flow is reduced. It follows that the specialist does not lose as much to the arbitrager by providing price continuity. But arbitrage order flow does not have to arrive to affect the way the specialist sets the bid-ask spread. The mere threat of one-sided arbitrage order flow can keep spreads from narrowing in spite of the reduction in observed volatility in the price series immediately after Rule 80A is triggered. Minute-by-minute volatility may not tell the whole story about the price adjustment process because it does not account for information that both the arbitrager and the specialist possess about where cash

prices are heading relative to futures prices.

Section 5. Concluding Remarks.

The 1990 amendment of NYSE Rule 80A, like the practice of stock index arbitrage it was designed to curtail, has become a controversial feature of U.S. financial markets. We find that Rule 80A significantly curtails--or "collars"-- index arbitrage activity. Sell-side and buy-side arbitrage subject to the rule's restrictions is about one third of what would be expected given the control period. Agency arbitrage is more severely constrained than principal index arbitrage. Sell-side and buy-side agency index arbitrage associated with the S&P 500 futures contract falls more than 90 percent relative to the control period. These results, consistent with the NYSE report (1991), are not consistent with the findings of Kuserk *et al* (1992) who conclude that "80A does not appear to be unduly constraining index arbitrage." We attribute the different findings to the different measures of index arbitrage volume. We are able to directly observe index arbitrage volume whereas Kuserk *et al*. infer arbitrage volume by observing basis behavior.

Despite the significant curtailment of index arbitrage activity, the cash and futures markets remain linked. Our evidence suggests that Rule 80A weakens the linkage between cash and futures markets in that pricing discrepancies between the markets are eliminated less quickly. Our results are consistent with the hypothesis that information is conveyed from one market to the other by means other than formal arbitrage. Specialist quote revision in anticipation of one-sided order flow and smart shopping by stock traders can explain why the virtual elimination of index arbitrage volume does not eliminate market linkage.

We also find that trading costs in the stock market, as measured by the average bid-ask

spread for S&P 500 stocks, do not change following the triggering of Rule 80A, in spite of the binding constraint on index arbitrage volume. Relative to the control group, both total trading volume (inversely related to the spread) and volatility (directly related to the spread) decline after Rule 80A is triggered. The overall impact of these opposing forces on bid-ask spreads is ambiguous. In addition, we find no change in futures market volatility attributable to Rule 80A.

In summary, our overall assessment of Rule 80A is that it has had little impact on trading costs and intermarket arbitrage despite significant curtailment of index arbitrage volume. Although we find statistically significant changes in market behavior after the triggering of Rule 80A, similar changes are also observed to occur on days of large price movements before Rule 80A's adoption. Therefore, we cannot conclude that these changes are attributable to Rule 80A.

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