The Effects of Amendments to Rule 80A on Liquidity, Volatility, and Price Efficiency in the S&P 500 Futures

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INTRODUCTION

This article attempts to isolate effects which a recent amendment to the New York Stock Exchange (NYSE) Rule 80A[1] has had on the pricing and microstructure of stock index futures markets, in particular, the Chicago Mercantile Exchange's (CME) S&P 500 stock index futures contract. The amendment to Rule 80A became effective on August 1, 1990, having been proposed in the aftermath of the October 1989 market volatility.[2] The rule constrains NYSE members, either as brokers or for proprietary purposes, while executing the stock side of index arbitrage, to execute such trades with a sell-plus (buy-minus) restriction during the remainder of a day after the Dow Jones Industrial Average (Dow) has fallen (risen) 50 points

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[1]Rule 80A generally refers to regulations on index arbitrage activity by NYSE members. From January 1988 until October 1988 there were restrictions on the use of the DOT system on volatile days. From October 1988 until the present there is a "side-car" procedure delaying program trades when the Dow moves 100 points.

[2]For an overview of the events of October 1989, see the United States Commodity Futures Trading Commission (1990).

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from the previous trading day's close. Unconstrained arbitrage is restored if the Dow reverses to within 25 points of the previous day's close. While the NYSE is open, members trading NYSE-listed stocks may do so only on the NYSE.[3] Nonmembers, such as institutions and other customers, are free to trade on the NYSE (through a member), on any other exchange (through a member), or over-the-counter (such as electronic principal-to-principal trading). While the volume of off-exchange trading may be growing, the speed and cost of execution required for profitable index arbitrage is probably not available at this time. In any case, there is no public record of any such activity.

The amendment to 80A was implemented under the premise that unconstrained index arbitrage can at times exacerbate price movements and volatility in the stock market. Documentation regarding the exact method in which this amendment was to curb such excess volatility is sparse.

In the *Federal Register* notice of the impending rule change, the Securities and Exchange Commission (SEC) stated:

> . . . the Exchange (NYSE) expressed the view that the "buys minus" and "sell plus" requirements for index arbitrage can be expected to have a favorable effect on minimizing excess market volatility and promoting market stabilization by ensuring that index arbitrage orders are executed in a stabilizing manner during periods of significant market volatility and thus cannot lead or accelerate additional movements upward (in the case of buy orders) or downward (in the case of sell orders) once the requirements are put into effect. (*United States Federal Register,* Vol 55, No. 59, p. 11284)

This study examines the effectiveness of the 80A rule change in bringing about the desired effect in situations of large price variability; namely, a delinking of the futures and cash markets, implying lower volatility in the cash markets. The NYSE and SEC do not state that they desire to delink these two markets; but, given the economics of the markets, this is a reasonable induction. This study also analyzes possible unanticipated harmful side effects of the 80A rule change such as increased futures market volatility and marketmaker harm.

EMPIRICAL FORMULATION

It has been shown empirically that, in the absence of regulatory or self-imposed constraints on index arbitrage, changes in the S&P 500 futures market tend to lead changes in the cash index, a weighted average of 500 stock prices.[4] The two prices, S&P 500 index futures and the cash index, are closely linked via investors seeking the cheaper market, and by index arbitragers making low-risk arbitrage trades when the opportunity arises. Insofar as amendments to 80A constrain index arbitrage during certain periods, two immediate effects can be hypothesized.

[3]This is due to NYSE Rule 390 which does allow exceptions for newly listed securities. Most transactions are bound by Rule 390 to be on the NYSE.

[4][See, e.g., Stoll and Whaley (1987), or Kawaller, Koch, and Koch (1986).] The nature of this lead-lag relationship is that macroeconomic events (interest rate moves, government announcements, etc.) affect all stocks to some degree (via the stock's covariance with the market), and the least cost method of trading against the value of all stocks is through derivative products such as index options and futures. Index arbitrage opportunities and action result from this lead-lag relationship, enforcing the law of one price across the stock and futures markets and stabilizing the futures/cash basis (see Furbush, 1989).

Hypothesis #1: The constraint on index arbitrage may result directly in increased futures/cash mispricing.

The 80A amendments were promulgated under the assumption that, during volatile times (at least 50-point Dow moves), unrestrained index arbitrage transmits volatility and excessive price movement from the stock index futures to the cash stock market. The constraint on index arbitrage must lead to misalignment in the basis, if the constraint is to have the desired effect. Since the rule assumes that, at a minimum, the stock market would be better off with constraints on index arbitrage, the logical deduction is that for the constraints on index arbitrage to "protect" cash from futures volatility they must lead to increased misalignment in the basis.

Previous periods with pronounced index arbitrage constraints have exhibited basis instability. Arbitrage was constrained in 1987 due to the clogging of the Designated Order Turnaround (DOT) system and political pressure or fears [see Furbush (1989)]. The basis during this period was often far from reasonable estimates of fair value. Also, there were voluntary restraints (apparently as a result of political pressure or regulatory fears) on Friday, October 13, 1989, when the S&P futures fell 30 points and futures closed at a discount to cash. The discount disappeared on Monday, October 16, 1989. In the absence of index arbitrage, market participants did not use the futures price in October 1987 or October 13, 1989, to infer cash values. Liquidity traders searching for the cheaper market did not realign the markets during these volatile periods. See United States Commodity Futures Trading Commission (1990) for details. These two markets, S&P 500 index futures and the underlying cash portfolio, price essentially the same market-wide risk. In fact, the literature on the S&P 500 reveals a tendency for the S&P 500 index futures to lead the cash index, even after adjusting for nonsynchronous trading in the cash index components. [see, e.g., Stoll and Whaley (1990); Kawaller, Koch, and Koch (1987)]. This study examines the S&P 500 futures' basis stability in the form of unit root tests and in the estimation of a modified error correction model. The maintenance of basis stability throughout the 80A period is considered to be a rejection of the effectiveness of 80A in segregating the markets.

Hypothesis #2: Given the real or perceived increased misalignment described in Hypothesis #1, there will be additional noise introduced into the economy, with respect to market-wide information revelation. Instead of one price for market-wide information, revealed in two markets linked by index arbitrage, there may be two segregated price discovery mechanisms, generating conflicting signals regarding systematic information.

Because the rule should lead to market segregation, the constraints on index arbitrage could lead to adverse side effects. Additional uncertainty generated by market segregation may exacerbate already increased volatility. With constrained index arbitrage, traders must induce the market's value of the S&P 500 from two prices, the futures and cash, which may be misaligned to a greater degree than when unconstrained arbitrage integrates the markets. Also, arbitrage supplies liquidity to markets, and the lack of arbitrage may be associated with less liquid markets, and increased gross short-run volatility. Both futures marketmakers and customers may be harmed by additional uncertainty and illiquidity brought on by the 80A restrictions. This study tests for the direct effect of the amendments to 80A on a variety of intraday measures.

DATA

The data used in this study come from two sources: the Time and Sales[5] record and the computerized trade reconstruction (CTR)[6] record of the CME. The sample includes three types of days. A control sample of volatility without arbitrage restraints is composed of 11 days in 1990 (which is prior to the implementation of index arbitrage restrictions) when the Dow moved by more than 50 points from the previous day's closing. This sample provides a benchmark of 50-point days with no regulatory constraints on index arbitrage. A second control sample includes days in August and October 1990 when the Dow did not move by 50 points. Finally, the days when index arbitrage was constrained by the imposition of 80A are examined. This sample selection allows the isolation of marginal effects which result from constraining index arbitrage with the tick test.

For marketmaking and volatility analysis, the point at which the Dow moves 50 points from its previous close is considered an event. The futures market is examined before and after this event, on both constrained and unconstrained days. The basis stability tests utilize data from either before the restriction or after the restriction on each day. The restriction on index arbitrage was generally triggered before 10:00 AM EST or after 3:45 PM EST, leaving several days of long time series with restricted arbitrage. Periods when the CME's price limits were effective are eliminated from the sample because there is potentially a prohibition of index arbitrage while a price limit is binding in one market.[7]

BASIS ERROR PERSISTENCE

Unit Roots

A test is conducted for the indirect effect of the rule in the form of increased misalignment in the basis.

The basis error, e_{bt}, in percentage terms, is defined as follows:

$$e_{bt} \equiv \log\left(\frac{F_t}{C_t}\right) - m(r - d) \tag{1}$$

[5]Time and sales contains every price in the S&P 500 futures following a price change and the time of the price change. It is considered to be an excellent source of intraday time and price data, and is input by a pit recorder at the CME with assistance from several pit observers. Time and sales is used and checked by floor traders, customers and brokers to validate trade times and prices. The time and sales record also contains a 15-second calculation of the S&P 500 index.

[6]The CTR contains every trade in the S&P 500 futures placed ex post via a computerized algorithm into one-minute execution brackets. Trades are identified by a variety of characteristics, including price and quantity, the customer type, and the opposing customer type. There are four customer types (CTI) identified on the CTR: CTI = 1, the floor trader is trading for his own account; CTI = 2, the floor trader is trading for his firm's account; CTI = 3, the floor trader is trading for another floor trader; CTI = 4, the floor trader is trading for a customer. The primary use of the CTR is for trade sequence and clearing purposes, not necessarily exact timing. However, CTR records with customer types 1 and/or 4, of most interest to this study, apparently have the highest timing accuracy due to the nature of the recordkeeping involved.

[7]In the case of stock index futures, this depends on whether the limited futures market is priced too high or too low relative to the underlying stocks. If the futures is locked limit down but trading at a premium, index arbitrage will be prohibited, as the required futures sell orders would not be executable in the futures market. However, if the futures is locked limit down but trading at a discount, the futures side of index arbitrage, which will now be a buy, can be executed, as the locked limit down indicates an excess of sell orders.

where F_t is the current value of futures, C_t is the current value of cash, m is the number of days until expiration of the futures contract, r is the interest rate relevant to the investor, and d is the dividend rate on the underlying index. A long futures position relative to cash forfeits dividends, but saves the interest which would be the opportunity cost of a cash position. Market choice by liquidity traders should keep the futures and cash markets aligned during normal times. For this analysis, a priori values for the cost of carry are not required, because it is the time path of the basis which is used in the unit root and error correction models. This is standard procedure in such models. If the basis error is not within transaction costs bounds, then index arbitrage is possible. Index arbitrage should lead to mean reversion in the basis. An additional source of the appearance of mean reversion could be nonsynchronous trading in the cash index component stocks. Serial correlation is eliminated in the series (whether due to nonsynchronous trading, bid–ask bounce, etc.) through the use of lagged values of the respective series. Remaining links between futures and cash should be interrupted by the triggering of Rule 80A.

Figure 1 depicts the average absolute basis error in the hour surrounding a Dow 50-point move in the sample period (January–October, 1990). On non-80A days, the average absolute basis error appears stable around the Dow's 50-point move. On 80A days, the average absolute basis rises *before* the Dow reaches 50 points, and the rule becomes effective. By 20 minutes after the Dow hitting 50 points, the average absolute basis error returns to its normal level. The discovery of this anticipatory and transient phenomenon is discussed later. The effect is clearly transitory and should not necessarily be directly attributed to constrained arbitrage.

A test is conducted for the presence of a unit root in the basis independently for each day. The unit root tests establish the stability of the basis and the cointegration of cash and futures. After establishing the cointegration of the two markets, a modi-

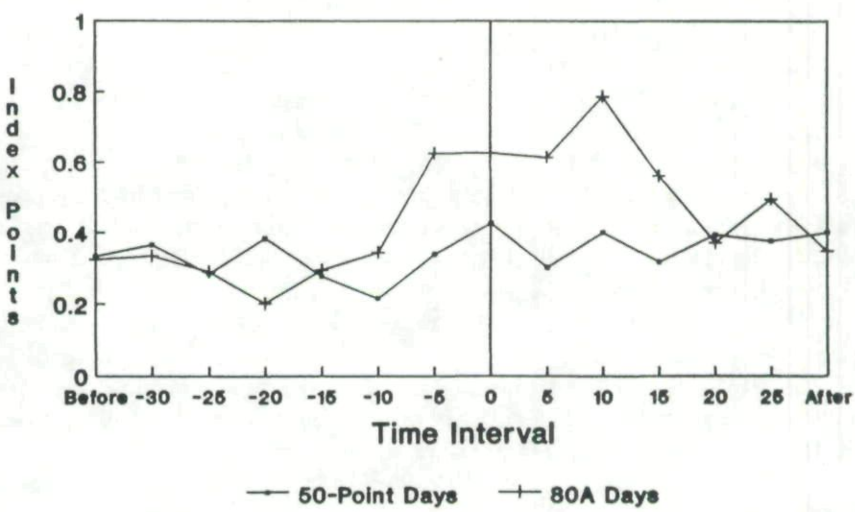

Figure 1

Average absolute basis error surrounding 50-point dow moves (January–October 1990). (*Note:* Basis error is calculated relative to daily average basis. Average absolute errors are calculated for five-minute intervals, and then these are averaged across days by time interval relative to the event of the Dow hitting 50 points. The 50-point days exclude the 80A days. Thus, each plot is of a separate sample.)

fied error correction model is estimated. The modified error correction estimation assigns the established basis stability to the two prices whose difference forms the basis. If basis errors tend to lead the cash, futures, or both, then coefficients on the basis error in the modified error correction model will reveal this, and will also reveal whether this relationship changes during the 80A periods.

If the markets are integrated, the intraday time series for the basis should not have a unit root. The presence of a unit root indicates that the basis is not stable. While the failure to reject a unit root is not a powerful test for a random walk, it is assumed to be evidence of a high degree of persistence in the basis error. Furbush (1989) and others have shown that index arbitrage enforces basis stability, with the basis reverting toward a daily fair value, as determined by interest and dividend rates. This stability is empirically revealed in this study through a rejection of a unit root in the basis. Clearly, there is more required than the triggering of 80A to induce observed instability in the basis over the short run. In addition to 80A, there must be a pattern of trading which pushes the two prices apart, or at least does not lead the two prices together. In fact, if there were little trading activity following the triggering of 80A, the basis might appear unstable, with low volatility. This study assumes that 80A does not influence the forces which would induce instability in the absence of index arbitrage restrictions. It then tests whether Rule 80A does lead to increased instability, by looking at the frequency of unstable days.

The three series, cash, futures, and basis, are tested for the presence of unit roots at frequencies of one miniute using the standard augmented Dickey–Fuller test [see Fuller (1976)]. For 50-point and 80A days, data from after the DOW hits 50 points from the previous day's close are used. When this occurs, too late in the day, the data prior to the 50-point move are used and the period is referred to as "off," similar to a non-50-point day.

For each series the following equation is estimated using OLS:

$$\Delta x_t = \lambda x_{t-1} + \sum_{i=1}^{p} \beta_i \Delta x_{t-i} + e_t \tag{2}$$

Cash, futures, and the basis are substituted sequentially for x_t in the regression equation. The test for a unit root is a test of whether λ is significantly different than zero. Results from the regressions are presented in Tables IA and IB. A lag length of $p = 10$ minutes is used in all series to remove serial correlation. Other lag lengths are used, with similar results. Q-tests reject autocorrelation of residuals from the regressions at the 95% level for all regressions on all days. The hypothesis of a unit root is generally rejected for the basis, universally for post-July non-80A days, while tests on futures and cash generally fail to reject unit roots. This implies a cointegration of futures and cash during nonvolatile periods.

The results from testing for a unit root in the basis are summarized in Table II. At the 90% confidence level, 80A days are no different than 50-point days, however, both of these are seemingly different from non-50-point days, where a unit root in the basis is rejected universally. At the 95% level the rejection rate for 80A days falls considerably, although the significance of this fall is moot given the small sample. It is concluded that the 80A days are similar to 50-point days, so that increased volatility (the volatility which comes with the 50-point drop) rather than 80A per se leads to market segregation. There may be additional basis inefficiency induced by 80A, but more observations are required before this can be tested sufficiently. The number of days in the sample is a natural barrier to drawing stronger conclusions.

Error Correction

To examine the allocation of the basis adjustment between futures and cash markets, a modified error correction model [see Engle and Granger (1987)] is estimated. The model is specified as follows:

$$\Delta c_t = \sum_{i=1}^{10} \beta_i^c \Delta c_{t-i} + \sum_{i=0}^{10} \gamma_i^c \Delta f_{t-i} + \eta_c e_{bt} + e_t^c \tag{3}$$

$$\Delta f_t = \sum_{i=1}^{10} \beta_i^f \Delta c_{t-i} + \sum_{i=1}^{10} \gamma_i^f \Delta f_{t-i} + \eta_f e_{bt} + e_t^f \tag{4}$$

where c_t and f_t are the logarithms of the cash index and the index futures price, respectively; $e_{bt} = (f_t - c_t) - \hat{b}$, where $\hat{b}$ is a parameter estimating each day's cost of carry, which is subsumed into the regression's intercept term; the errors are stationary. Established economics of the futures–cash relationship assist in defining this modified error correction model. Changes in the logarithms of futures and cash prices are assumed to be affected by errors in the basis, rather than by an endogenous linear combination of the two variables. The lags in the model pick up any remaining serial correlation (nonsynchronicity, etc.). The model is estimated using OLS on the same data used for the unit root tests.

Table IIIA and IIIB present the basis error coefficients for both equations along with the root mean squared error from each equation. Due to space considerations the lag structure from each equation is not reported. The signs of the basis error coefficients are consistent with market integration and theory. Large basis errors are a signal that futures are too high relative to cash; thus one expects the basis error coefficient to be positive in the cash equation and negative in the futures equation. These are the estimated signs, although the cash estimates are significant more often than the futures. This relationship is consistent on 80A and non-80A days.[8] The average basis error coefficient for the "off" periods is 0.0629, while the average basis coefficient for the "on" periods is 0.0470, and for the 50-point but non-80A days is 0.0682. Simple means tests reveal that these average coefficients are not significantly different from each other, even though some may find it appealing that the point estimate for the 80A basis error coefficient is smaller than either the nonvolatile or control coefficient. A significantly smaller coefficient would imply that cash is less responsive to basis errors, indicating a significant effect of 80A in delinking the markets.

The results suggest that an 80A day is similar to previous 50-point days, as far as basis (in)stability is concerned. On volatile (50-point) days liquidity costs rise in both cash and futures markets, forcing index arbitrageurs to wait for a wider basis before submitting arbitrage orders. In fact, because of the increased importance of liquidity costs versus fixed trading costs, tick-sensitive arbitrage becomes more attractive to arbitrageurs. The natural costs of trading which rise with volatility impose economic constraints on index arbitrage, which may be reinforced by political fears. Under such a scenario, Rule 80A need not be a significant constraint. Therefore, the first hypothesis, 80A leads to increased misalignment in the basis, is rejected.

[8]Since, on several 80A days, the presence of a unit root in the basis is not rejected, the basis is not stationary. Thus only those days when the basis did not have a unit root should be compared in the error correction modeling.

Table IA

UNIT ROOT TESTS, S&P 500 CASH, FUTURES, AND BASIS (AUGUST–OCTOBER 1990)

Regression equations are of the form:

$$\Delta x_t = \lambda x_{t-1} + \sum_{i=1}^{10} \beta_i \Delta x_{t-i} + e_t$$

Estimates of λ and Augmented Dickey–Fuller (τ_μ) Statistic

			Cash		Futures		Basis	
Date	Obs.	80A	Coef.	τ	Coef.	τ	Coef.	τ
Aug. 3	197	on	0.0038	(0.652)	0.0005	(0.036)	−0.1497	(−2.733)[a]
Aug. 6	326	on	−0.0154	(−2.909)[b]	−0.0650	(−3.188)[b]	−0.1193	(−3.819)[b]
Aug. 7	367	off	−0.0097	(−2.527)	−0.0238	(−2.486)	−0.1848	(−4.934)[b]
Aug. 8	369	off	−0.0063	(−1.971)	−0.0163	(−2.005)	−0.1310	(−3.486)[b]
Aug. 9	369	off	−0.0025	(−0.808)	−0.0064	(−0.770)	−0.1546	(−4.211)[b]
Aug. 10	131	on	−0.0175	(−1.554)	−0.0301	(−1.512)	−0.1146	(−2.156)
Aug. 13	369	off	0.0004	(0.197)	0.0003	(0.065)	−0.1049	(−3.739)[b]
Aug. 14	369	off	−0.0061	(−1.543)	−0.0100	(−1.429)	−0.1046	(−3.513)[b]
Aug. 15	369	off	−0.0080	(−1.651)	−0.0201	(−1.969)	−0.1107	(−3.660)[b]
Aug. 16	352	off	−0.0026	(−0.837)	−0.0075	(−0.788)	−0.1885	(−4.109)[b]
Aug. 17	208	on	0.0037	(0.755)	−0.0012	(−0.061)	−0.1690	(−2.833)[a]
Aug. 20	369	off	−0.0170	(−2.275)	−0.0317	(−2.228)	−0.1882	(−4.528)[b]
Aug. 21	152	on	−0.0318	(−2.238)	−0.0670	(−2.251)	−0.2277	(−3.476)[b]
Aug. 22	369	off	−0.0092	(−2.368)	−0.0192	(−1.812)	−0.1817	(−4.108)[b]
Aug. 23	355	on	−0.0064	(−1.844)	−0.0148	(−1.324)	−0.0640	(−2.560)
Aug. 24	359	off	−0.0037	(−1.287)	−0.0083	(−1.078)	−0.2909	(−6.238)[b]
Aug. 27	367	on	−0.0095	(−2.306)	−0.0147	(−1.613)	−0.0919	(−4.832)[b]
Aug. 30	359	off	0.0008	(0.185)	−0.0000	(−0.005)	−0.2508	(−4.895)[b]

Sept. 20	345	off	−0.1460	(−2.998)	−0.0267	(−2.358)	−0.1437	(−3.423)[b]
Sept. 24	313	on	−0.0124	(−2.384)	−0.0385	(−2.324)	−0.1039	(−2.852)[a]
Sept. 27	211	on	−0.0170	(−2.114)	−0.0395	(−1.994)	−0.1492	(−3.024)[b]
Oct. 1	214	on	−0.0096	(−1.510)	−0.0598	(−2.811)[a]	−0.1012	(−2.854)[a]
Oct. 2	369	off	−0.0001	(−0.028)	0.0004	(0.036)	−0.1431	(−3.908)[b]
Oct. 3	369	off	−0.0003	(−0.106)	−0.0023	(−0.305)	−0.0931	(−3.203)[b]
Oct. 4	369	off	−0.0063	(−1.498)	−0.0137	(−1.507)	−0.1542	(−4.117)[b]
Oct. 5	57	on	0.0227	(1.484)	0.1507	(1.414)	−0.2996	(−1.941)
Oct. 8	369	off	−0.0179	(−3.299)[b]	−0.0451	(−3.234)[b]	−0.0825	(−3.348)[b]
Oct. 9	62	on	−0.0232	(−1.627)	0.0134	(0.446)	−0.0483	(−0.827)
Oct. 10		on	…	…	…	…	…	…
Oct. 11	132	on	−0.0303	(−1.952)	−0.2000	(−3.119)[b]	−0.2373	(−3.266)[b]
Oct. 12	369	off	−0.0050	(−1.647)	−0.0145	(−1.716)	−0.1939	(−4.361)[b]
Oct. 15	369	off	−0.0019	(−0.853)	−0.0052	(−0.850)	−0.1996	(−4.344)[b]
Oct. 16	369	off	−0.0023	(−0.810)	−0.0085	(−1.220)	−0.1590	(−4.088)[b]
Oct. 17	370	off	−0.0085	(−1.922)	−0.0210	(−2.090)	−0.1780	(−4.946)[b]
Oct. 18	219	on	−0.0082	(−1.369)	−0.0201	(−1.133)	−0.1192	(−2.986)[b]
Oct. 19		on	…	…	…	…	…	…
Oct. 22	369	off	−0.0025	(−1.171)	−0.0105	(−1.587)	−0.1355	(−3.806)[b]
Oct. 23	369	off	−0.0091	(−1.629)	−0.0246	(−1.715)	−0.1993	(−5.020)[b]
Oct. 24	369	off	−0.0064	(−1.359)	−0.0141	(−1.457)	−0.0841	(−3.048)[b]
Oct. 25	369	off	−0.0121	(−2.842)[a]	−0.0269	(−2.471)	−0.1748	(−4.167)[b]
Oct. 26	369	off	0.0019	(0.454)	0.0019	(0.199)	−0.0918	(−3.224)[b]
Oct. 29	370	off	−0.0012	(−0.695)	−0.0026	(−0.709)	−0.0971	(−3.541)[b]
Oct. 30	369	off	−0.0015	(−0.523)	−0.0056	(−0.824)	−0.1174	(−3.440)[b]
Oct. 31	369	off	0.0004	(0.079)	−0.0140	(−1.324)	−0.1030	(−3.171)[b]

[a]90% Significance; [b]95% Significance.

Note: End-of-minute (logarithms of) cash, futures, and the relative basis are substituted for x. Failure to reject a unit root in the cash and futures equation coupled with a rejection of a unit root in the basis equation implies cointegration of futures and cash. τ_μ If from Fuller (1976, p. 373) and is a test of the null hypothesis $\lambda = 0$.

Table IB
UNIT ROOT TESTS, S&P 500 CASH, FUTURES, AND BASIS
(PRE-80A AMENDMENT 50-POINT DOW DAYS)

Regression equations are of the form:

$$\Delta x_t = \lambda x_{t-1} + \sum_{i=1}^{10} \beta_i \Delta x_{t-i} + e_t$$

Estimates of λ and Augmented Dickey–Fuller (τ_μ) Statistic

		Cash		Futures		Basis	
Date	**Obs.**	**Coef.**	**τ**	**Coef.**	**τ**	**Coef.**	**τ**
Jan. 2	368	0.0019	(0.523)	−0.0129	(−1.600)	−0.0569	(−2.019)
Jan. 12	320	0.0007	(0.189)	0.0046	(0.594)	−0.0368	(−1.700)
Jan. 22	61	−0.0019	(−0.147)	0.0018	(0.047)	−0.4209	(−3.129)[a]
Jan. 24	368	0.0004	(0.143)	−0.0092	(−1.154)	−0.0348	(−3.228)[a]
Jan. 25	369	−0.0013	(−0.429)	−0.0042	(−0.620)	−0.1554	(−4.166)[a]
Feb. 2	142	−0.0079	(−0.972)	−0.0289	(−1.459)	−0.1649	(−3.038)[a]
May 11	113	−0.0096	(−0.873)	−0.0231	(−1.190)	−0.1884	(−2.118)
May 14	168	−0.0132	(−1.637)	−0.0428	(−2.396)	−0.2444	(−4.393)[a]
May 29	369	0.0006	(0.205)	0.0037	(0.612)	−0.1399	(−3.449)[a]
June 18	369	−0.0030	(−0.951)	−0.0108	(−1.675)	−0.1738	(−5.024)[a]

[a]95% Significance.

Note: End-of-minute (logarithms of) cash, futures, and the relative basis are substituted for x. Failure to reject a unit root in cash and futures coupled with rejection of a unit root in the basis implies cointegration of futures and cash. τ_μ Statistic is from Fuller (1976, p. 373) and tests the null hypothesis that $\lambda = 0$.

Table II
SUMMARY OF RESULTS FROM UNIT ROOT TESTS

		Days Unit Root Rejected	
Type of Day	**No. of Days in Sample**	**90% Conf.**	**95% Conf.**
No 50-point move	28	28 (100%)	28 (100%)
50-point move, no 80A	10	7 (70%)	7 (70%)
80A days	14	10 (71%)	6 (43%)

SIDE EFFECTS

Methodology

The second hypothesis, whether 80A harms the markets, is now examined. Several measures from the S&P 500 index futures market are calculated to capture any indirect, unintended effects of 80A on market depth, liquidity, volatility, or marketmaking activity or profitability. Each measure is used as the dependent variable in an OLS regression using a large set of indicator variables designed to factor out effects unrelated to the triggering of 80A. The intercept is dropped from the regression, and the indicator variables are defined so that the estimated 80A parameters are incremental effects of the rule. Normal intraday patterns of the respective measures are accounted for through the use of 13 intraday indicator variables: six five-minute opening dummies spanning 9:30 AM EST to 10:00 AM, six five-minute closing dummies spanning 3:45 PM EST to 4:15, and a MIDDAY dummy equal to unity after 10:00 AM EST and before 3:45 PM EST.[9] Due to the peculiar early morning or late afternoon timing of the majority of 80A events, these time-of-day dummies are used to avoid contamination of regulatory effects by normal opening and closing volatility. Since several of the days are also instances of the triggering of the CME's five-point opening price limit, this is modeled as a delayed opening, and a dummy equal to unity for the first half hour after the expiration of the five-point limit (9:45 AM to 10:15 AM) is included.

Finally, two sets of 14 indicator variables are used to account for any 50-point effects and any 80A effects. Each set spans the entire day, with increased precision in the hour surrounding the triggering of 80A. A "BEFORE" dummy is equal to unity prior to one-half hour before the Dow reaches 50 points from the previous day's close. An "AFTER" dummy is equal to unity after one-half hour from the time the Dow reaches 50 points from the previous day's close. In the hour immediately surrounding the 50-point event there are 12 indicator variables each equal to unity for a particular five minutes (t-30, t-25, . . . , t, $t + 5$, . . . $t + 25$), where t is the five-minute bracket during which the Dow movement equaled 50 points, and $t + k$ is the bracket from $t + k$ until $t + k + 5$. The 14 variables associated with 50-point moves are equal to unity for the appropriate five-minutes or "BEFORE" or "AFTER" period on all 50-point days, 80A and non-80A. The 14 80A variables are equal to unity only on 80A days, thus allowing for the interpretation of the estimated parameters on these 80A variables as the incremental effects of 80A.[10] The data are from 30 days when the Dow moved 50 points, of which 16 are days when arbitrage was constrained by 80A for a significant number of minutes. Twenty-eight recent days, when the Dow did not move 50 points, are included to establish the intraday patterns.

Marketmaker Profitability

The first set of variables, designed to measure marketmaking profitability, are examined. The futures marketmaking sector is harmed by the constraint if profits for this group tend to fall during constrained arbitrage periods. This is of concern, because a fall in marketmaker profitability is expected to be made up at the customer's expense through wider bid–ask spreads and less liquidity. Two measures, marketmaking activity and unit profit, are examined. For activity, the participation rate of marketmakers in customer trades is examined. For unit profit, the average turnaround price for the marketmaking sector over a short interval is measured. The combination of these two measures allows for evaluation of marketmaker profitability over short intervals. If unit profit is constant or even rising during the constrained period, profits may yet be falling if participation rates are falling, and marketmakers face an opportunity cost for time and a positive seat rental value.

Marketmaker unit profit is an aggregate, per-contract measure, and not a measure of individual marketmakers' profitability. Likewise, participation rates are an aggre-

[9]Intraday patterns in volatility and liquidity are well established in the literature. For the specific intraday patterns in the S&P 500 futures wee Wang et al. (1989). Dummy variables for the 4:00–4:15 period while the rule was in effect were included originally but these proved insignificant and were, therefore, not reported.

[10]As a caveat, note that the 80A days are later in the sample, and the non-80A 50-point days are earlier in the sample period. If there was any non-80A related change in behavior over the sample period, this will be captured by the 80A indicator variables as well. No significant institutional change during this period was evident.

Table IIIA
MODIFIED ERROR CORRECTION MODEL (AUGUST–OCTOBER 1990)

Regression equations are:

$$\Delta f_t = \sum_{i=1}^{10} \beta_i^f \Delta f_{t-i} + \sum_{i=1}^{10} \gamma_i^f \Delta C_{t-i} + \eta_f e_{bt} + e_t^f$$

$$\Delta C_t = \sum_{i=0}^{10} \beta_i^c \Delta f_{t-i} + \sum_{i=1}^{10} \gamma_i^c \Delta c_{t-i} + \eta_c e_{bt} + e_t^c$$

Coefficients on Lagged Basis Error (η_i)

			Futures Equation			Cash Equation		
Date	80A	Obs.	Coef.	t-Stat.	Root MSE	Coef.	t-Stat.	Root MSE
Aug. 3	on	197	−0.0848	(−1.111)	7.45×10^{-4}	0.0705	(3.694)	1.86×10^{-4}
Aug. 6	on	326	−0.0943	(−2.148)	8.29×10^{-4}	0.0141	(1.832)	1.45×10^{-4}
Aug. 7	off	367	−0.0941	(−2.057)	6.80×10^{-4}	0.0493	(3.253)	2.24×10^{-4}
Aug. 8	off	369	−0.0532	(−1.232)	4.81×10^{-4}	0.0437	(3.024)	1.61×10^{-4}
Aug. 9	off	369	−0.0767	(−1.785)	3.76×10^{-4}	0.0574	(3.826)	1.31×10^{-4}
Aug. 10	on	131	−0.1162	(−1.917)	4.15×10^{-4}	0.0228	(0.898)	1.71×10^{-4}
Aug. 13	off	369	0.0125	(0.332)	4.05×10^{-4}	0.0594	(4.306)	1.48×10^{-4}
Aug. 14	off	369	0.0147	(0.397)	4.15×10^{-4}	0.0535	(3.359)	1.78×10^{-4}
Aug. 15	off	369	−0.0631	(−1.913)	3.89×10^{-4}	0.0308	(2.638)	1.37×10^{-4}
Aug. 16	off	352	−0.0761	(−1.354)	5.06×10^{-4}	0.0705	(4.330)	1.46×10^{-4}
Aug. 17	on	208	−0.2521	(−2.774)	7.50×10^{-4}	0.0562	(3.442)	1.32×10^{-4}
Aug. 20	off	369	−0.0956	(−2.249)	4.46×10^{-4}	0.0712	(3.367)	2.21×10^{-4}
Aug. 21	on	152	0.1628	(1.303)	7.14×10^{-4}	0.1815	(3.837)	2.69×10^{-4}
Aug. 22	off	369	0.0067	(0.109)	8.08×10^{-4}	0.1020	(5.306)	2.51×10^{-4}
Aug. 23	on	355	−0.0126	(−0.376)	9.44×10^{-4}	0.0230	(3.078)	2.10×10^{-4}
Aug. 24	off	359	−0.2443	(−3.513)	6.59×10^{-4}	0.1338	(5.819)	2.14×10^{-4}
Aug. 27	on	367	−0.0528	(−2.106)	5.27×10^{-4}	0.0547	(6.089)	1.88×10^{-4}

Aug. 30	off	359	−0.0776	(−1.096)	4.75×10^{-4}	0.1394	(4.740)	1.97×10^{-4}
Sept. 20	off	345	−0.1259	(−2.804)	4.93×10^{-4}	0.0273	(1.886)	1.57×10^{-4}
Sept. 24	on	313	−0.0857	(−1.955)	8.20×10^{-4}	0.0233	(2.324)	1.86×10^{-4}
Sept. 27	on	211	−0.1179	(−1.542)	6.49×10^{-4}	0.0667	(2.860)	1.97×10^{-4}
Oct. 1	on	214	−0.1051	(−2.501)	5.57×10^{-4}	0.0105	(1.119)	1.23×10^{-4}
Oct. 2	off	369	−0.0107	(−0.224)	5.96×10^{-4}	0.0784	(4.688)	2.08×10^{-4}
Oct. 3	off	369	0.0004	(0.011)	5.77×10^{-4}	0.0393	(3.505)	1.73×10^{-4}
Oct. 4	off	369	0.0059	(0.116)	6.17×10^{-4}	0.0810	(4.675)	2.10×10^{-4}
Oct. 5	on	57	−0.2063	(−0.948)	9.67×10^{-4}	0.0165	(0.659)	1.10×10^{-4}
Oct. 8	off	369	−0.0249	(−0.778)	4.08×10^{-4}	0.0363	(3.605)	1.28×10^{-4}
Oct. 9	on	62	−0.0902	(−0.877)	9.22×10^{-4}	−0.0218	(−1.427)	1.35×10^{-4}
Oct. 10	on		...	...	...	...	...	...
Oct. 11	on	132	−0.0661	(−0.526)	11.01×10^{-4}	0.0736	(3.734)	1.73×10^{-4}
Oct. 12	off	369	−0.0616	(−1.043)	7.83×10^{-4}	0.0825	(4.233)	2.58×10^{-4}
Oct. 15	off	369	−0.0982	(−1.707)	8.67×10^{-4}	0.0529	(3.080)	2.57×10^{-4}
Oct. 16	off	369	−0.0675	(−1.298)	6.86×10^{-4}	0.0602	(3.524)	2.25×10^{-4}
Oct. 17	off	370	0.0107	(0.183)	6.49×10^{-4}	0.0987	(4.881)	2.24×10^{-4}
Oct. 18	on	219	0.1085	(1.345)	6.89×10^{-4}	0.0664	(3.128)	1.81×10^{-4}
Oct. 19	on		...	...	...	...	...	...
Oct. 22	off	369	−0.0880	(−2.082)	5.48×10^{-4}	0.0432	(3.358)	1.66×10^{-4}
Oct. 23	off	369	−0.1433	(−2.642)	5.87×10^{-4}	0.0797	(4.544)	1.87×10^{-4}
Oct. 24	off	369	−0.0548	(−2.035)	5.32×10^{-4}	0.0223	(1.968)	2.23×10^{-4}
Oct. 25	off	369	−0.0770	(−1.509)	5.96×10^{-4}	0.0632	(3.597)	2.05×10^{-4}
Oct. 26	off	369	0.0712	(1.844)	5.14×10^{-4}	0.0450	(3.774)	1.58×10^{-4}
Oct. 29	off	370	−0.0063	(−0.190)	5.63×10^{-4}	0.0364	(3.093)	1.99×10^{-4}
Oct. 30	off	369	−0.0443	(−0.956)	6.73×10^{-4}	0.0621	(4.217)	2.13×10^{-4}
Oct. 31	off	369	−0.0292	(−0.727)	5.54×10^{-4}	0.0426	(3.629)	1.62×10^{-4}

Note: Unreported lag structures and other regression diagnostics all appeared nonproblematic.

Table III B

MODIFIED ERROR CORRECTION MODEL (PRE-80A AMENDMENT 50-POINT DOW DAYS)

Regression equations are:

$$\Delta f_t = \sum_{i=1}^{10} \beta_i^f \Delta f_{t-i} + \sum_{i=1}^{10} \gamma_i^f \Delta c_{t-i} + \eta_f e_{bt} + e_t^f$$

$$\Delta c_t = \sum_{i=0}^{10} \beta_i^c \Delta f_{t-i} + \sum_{i=1}^{10} \gamma_i^c \Delta c_{t-i} + \eta_c e_{bt} + e_t^c$$

Coefficients on Lagged Basis Error (η_i)

		Futures Equation			Cash Equation		
Date	Obs.	Coef.	*t*-Stat.	Root MSE	Coef.	*t*-Stat.	Root MSE
Jan. 2	368	−0.0898	(−3.174)	3.65×10^{-4}	−0.0197	(−1.488)	1.69×10^{-4}
Jan. 12	320	0.0151	(0.600)	6.02×10^{-4}	0.0111	(1.440)	1.84×10^{-4}
Jan. 22	61	−0.1059	(−0.528)	9.30×10^{-4}	0.1381	(2.387)	2.68×10^{-4}
Jan. 24	368	−0.0323	(−3.044)	8.61×10^{-4}	0.0045	(1.445)	2.52×10^{-4}
Jan. 25	369	0.0157	(0.281)	6.15×10^{-4}	0.0710	(4.043)	1.94×10^{-4}
Feb. 2	142	−0.1066	(−1.516)	3.53×10^{-4}	0.0546	(2.370)	1.14×10^{-4}
May 11	113	0.1702	(1.106)	4.60×10^{-4}	0.1161	(1.641)	2.10×10^{-4}
May 14	168	−0.1918	(−2.503)	5.55×10^{-4}	0.0754	(2.855)	1.88×10^{-4}
May 29	369	−0.0695	(−1.182)	3.55×10^{-4}	0.1486	(6.353)	1.41×10^{-4}
Jun. 18	369	−0.0531	(−1.324)	3.91×10^{-4}	0.0818	(4.835)	1.64×10^{-4}

Note: Unreported lag structures and other regression diagnostics all appeared nonproblematic.

gate measure; no attempt is made to measure a change in the number of floor traders (a number not recorded by the exchange), but rather a change in the existing floor traders' participation in customer trades.

As a proxy for short run marketmaking profitability, marketmaker-to-customer execution spreads in the S&P 500 futures market are examined. The marketmaker-to-customer execution spread over an interval is the average price marketmakers receive from customers for a contract minus the average price marketmakers pay customers for a contract within the interval. The execution spread is measured in S&P points (multiply the execution spread by \$500 to figure dollar values).

Marketmaker unit profit (the execution spread), π_τ, over interval τ is given by the following:

$$\pi_\tau = \frac{\sum_{i=1}^{k_s} P_i^s * Q_i^s}{\sum_{i=1}^{k_s} Q_i^s} - \frac{\sum_{i=1}^{k_b} P_i^b * Q_i^b}{\sum_{i=1}^{k_b} Q_i^b} \tag{5}$$

where:

P_i^s = price of sale i by a marketmaker,
Q_i^s = quantity of sale i by a marketmaker,
P_i^b = price of buy i by a marketmaker,
Q_i^b = quantity of buy i by a marketmaker, and
k_s, k_b = sell and buy transactions by marketmakers.

For participation rates, the rate at which floor traders are opposite customers, as a fraction of all trading by customers, are examined. This is measured separately for customer buys and sells within each five-minute interval. (Customers may bypass marketmakers if two brokers have matching orders and manage to execute their trade.)

Participation rates, ρ^b and ρ^s, for marketmakers as a percentage of customer buys and sells, over interval τ, are defined:

$$\rho^b = \frac{\sum_i (Q_i | \text{customer buys from marketmaker})}{\sum_j (Q_j | \text{customer buys})} \tag{7}$$

$$\rho^s = \frac{\sum_i (Q_i | \text{customer sells to marketmaker})}{\sum_j (Q_j | \text{customer sells})} \tag{8}$$

If the marketmaking sector is harmed by the triggering of 80A, then unit profit will fall, or participation rates will fall, or both.[11]

Results for marketmaking profitability and participation are presented in Table IV. The MIDDAY mean execution spread is 0.0225, less than half of a mini-

[11]Customer volume is assumed to be exogenous to the marketmaking sector over the short run. The evidence regarding the interrelationship between volume and volatility in futures markets in inconclusive. The direct effect of eliminating some index arbitrage trades should be a minor decrease in customer volume. In fact, index arbitrage trades will compete with marketmakers since index arbitrage orders will be entered against the prevailing customer flow.

Table IV
MARKETMAKER ACTIVITY AND RULE 80A

Unit Profit = Average Local Sell Price − Average Local Buy Price
Participation Rate = Marketmaker Fraction of Customer Sales (Buys)

	Unit Profits		Participation Rate: Buys		Participation Rate: Sells	
Variable	**50-Point Effect**	**80A Effect**	**50-Point Effect**	**80A Effect**	**50-Point Effect**	**80A Effect**
Time = $(t - 30)$	−0.0225	0.0350	0.0368	0.0039	0.0133	−0.0260
	(−0.480)	(0.652)	(0.414)	(0.039)	(0.153)	(−0.262)
Time = $(t - 25)$	0.0038	−0.0404	0.0391	−0.0064	0.0395	−0.1487
	(0.081)	(−0.745)	(0.441)	(−0.063)	(0.456)	(−1.486)
Time = $(t - 20)$	0.0096	0.0211	0.0045	0.0496	−0.0231	0.0385
	(0.203)	(0.393)	(0.050)	(0.489)	(−0.267)	(0.388)
Time = $(t - 15)$	0.0238	−0.0606	0.0091	0.0816	0.0543	0.0056
	(0.505)	(−1.130)	(0.103)	(0.804)	(0.625)	(0.057)
Time = $(t - 10)$	−0.0355	0.0514	−0.0182	0.0200	0.0294	−0.1237
	(−0.843)	(1.038)	(−0.229)	(0.213)	(0.378)	(−1.353)
Time = $(t - 5)$	0.1148	−0.0712	−0.0992	0.1063	−0.1456	0.0726
	(2.723)	(−1.461)	(−1.245)	(1.155)	(−1.870)	(0.807)
Time = (t)	0.1138	−0.0956	−0.0541	0.0389	−0.1009	−0.0114
	(2.699)	(−1.962)	(−0.679)	(0.423)	(−1.296)	(−0.127)
Time = $(t + 5)$	0.0691	−0.0763	−0.0903	0.0870	−0.1054	0.0256
	(1.639)	(−1.576)	(−1.133)	(0.951)	(−1.354)	(0.287)
Time = $(t + 10)$	0.0206	0.0044	−0.0161	0.1103	−0.0794	−0.0025
	(0.489)	(0.091)	(−0.202)	(1.213)	(−1.020)	(−0.028)

Time = (t + 15)	0.0531	−0.0463	−0.0092	0.0850	−0.0664	0.0526
	(1.259)	(−0.963)	(−0.115)	(0.935)	(−0.853)	(0.591)
Time = (t + 20)	−0.0292	0.0151	0.0489	0.0309	0.0251	−0.0267
	(−0.693)	(0.314)	(0.615)	(0.340)	(0.323)	(−0.300)
Time = (t + 25)	0.0289	−0.0519	−0.1183	0.2068	−0.0691	0.0117
	(0.688)	(−1.066)	(−1.488)	(2.249)	(−0.889)	(0.131)
Before 50 point	0.0043	—	0.0011	—	−0.0116	—
	(0.620)		(0.086)		(−0.913)	
After 50 point	−0.0010	—	0.0238	—	0.0374	
	(−0.148)		(1.818)		(2.923)	
Before 80A	—	−0.0099	—	0.0818	—	0.0219
		(−1.332)		(5.821)		(1.597)
After 80A	—	−0.0076	—	−0.0208	—	−0.0775
		(−1.026)		(−1.479)		(−5.630)
Midday	0.0225		0.6140		0.6152	
	(8.582)		(123.994)		(127.100)	
Post-5-point limit	0.0741		−0.1142		−0.0786	
	(4.293)		(−3.501)		(−2.464)	
F-test for significance	F = 1.2048		F = 3.3322		F = 2.8364	
of 80A variables	P = 0.2640		P = 0.0001		P = 0.0003	

Notes: t-statistics in parentheses; 50-point variables include both pre- and postamendment data. 80A variables represent incremental effect of 80A. Before and after 50-point (80A) covers the parts of the day, not in the half-hour before and after the DOW hits 50 points. Measures are calculated over five-minute intervals. The 50-point effect is the common effect for both 80A and non-80A days when the Dow moves 50 points. Thus, the estimated 80A parameters are the incremental effects of 80A.

mum price change (0.05). This yields a turnaround profit of $11.25 per contract. Unit profitability, in the form of short-run execution spreads, is not significantly affected by the triggering of 80A. Only one of the 12 five-minute indicator variables is significant at the 90% level. The 80A variables are jointly insignificant as shown by the *F*-test. The AFTER variable is insignificant. Similar results hold for the Dow hitting 50 points in general, with the exception of the period immediately before and during the Dow hitting 50 points, when 0.11 S&P points are added to execution spreads. The Dow reaching 50 points appears to be a significant event, and is associated with increased unit profitability. It is concluded that S&P 500 index futures marketmaker unit profitability is not significantly affected by the constraint on index arbitrage. Also significant is the five-point opening limit. The expiration of the five-point limit is followed by an increase in execution spreads of 0.07, or $35 per contract.

Participation rate analysis yields mixed results; there is no overwhelming drop off in participation. The MIDDAY values for participation in customer buys and sells is 0.614 and 0.615, indicating that more than half of all customer S&P 500 contracts are traded with marketmakers. In the hour immediately surrounding the triggering of 80A, there is no significant change in marketmaker participation, except for a few intervals when participation significantly increases. However, the AFTER coefficient shows a significant decrease in participation with customer sales. The *F*-tests for participation in customer buys and sells fail to reject the joint significance test of all 80A variables. In the half-hour after the expiration of the CME's five-point opening limit participation rates fall by around 10%.

In summary, unit profitability is unaffected by 80A, and there are ambiguous results for marketmaker participation. There is no clear deterioration in marketmaker profitability. Insofar as 80A may reduce volume, this result must be revised accordingly. This study does not attempt to estimate the effect of 80A on volume.

Price Velocity and Mean Absolute Price Change

Other side effects to be investigated involve disturbances to short-run volatility and depth. An increase in volatility, due either to illiquidity or increased uncertainty, will lead to arbitrary wealth transfers between futures traders. Diminished depth of the market indicates that customers are paying more for liquidity services. For volatility measures, price velocity and mean absolute price change are examined. Velocity, over an interval of time, is the average absolute price change per second. Velocity is an important complement to mean absolute price change in markets such as the S&P 500 futures which frequently trade at price differences of a minimum tick.[12] Time and sales captures every price change, at varying time intervals, and velocity may be more representative of volatility than standard deviation or mean absolute price change, and using such a measure allows full use of the time series.[13] To measure average velocity, the absolute value of the change in price is divided by the number of seconds between price changes, then averaged over a time interval.

[12]The minimum tick is the minimum allowable price change, which, in the case of the S&P 500 futures is 0.05 index points, or $25. The average absolute price change in the S&P 500 futures is generally found to be near 0.06, suggesting a preponderance of price changes of a minimum tick.

[13]For a discussion of some of the implications of such a time series see Neftci and Policano (1990). Neftci and Policano employ the incorrect assumption that the time and sales data represents trade by trade data. However, their analysis does yield some insight into the relationship between price and time.

Mean velocity over interval τ is defined:

$$v_\tau = \frac{1}{k} \sum_{i=1}^{k} \frac{|\Delta P_i|}{\Delta t_i} \tag{9}$$

where: Δt_i = the time between price changes, and k = the number of price changes in the interval.

Mean velocity must be compared with the contemporaneous measure of mean absolute price change. One may be able to extract volatility from any divergence between velocity and mean absolute price change.

Mean absolute price change over interval τ is given by:

$$m_\tau = \frac{1}{k} \sum_{i=1}^{k} |\Delta P_i| \tag{11}$$

Mean absolute price change and velocity results are presented in Table V. The MIDDAY estimate for the mean absolute price change is 0.0631 S&P points. Mean absolute price change is significantly affected by 80A. This effect is noticeable in the 15 minutes immediately *preceding* the triggering of 80A, the first five minutes after 80A, and the rest-of-the-day. At a peak, the triggering of 80A adds 0.04 S&P points to the mean absolute price change. Also, for comparison purposes, in the half hour following the expiration of the five-point limit, the mean absolute price change rises by 0.10.

Price velocity is mildly affected by 80A. The normal midday estimate of the velocity of the S&P 500 futures is 0.0105 S&P points per second. The entire 80A day (BEFORE, AFTER) shows a velocity increase of 0.0016 and 0.0015. Thus, velocity increases prior to the triggering of 80A and remains higher throughout the day. Since velocity does not increase upon the triggering of 80A, it is concluded that the observed increase in mean absolute price change overstates an increase in volatility.

It is important to note the anticipatory effect in mean absolute price change prior to the triggering of 80A, followed by a less volatile market for the rest of the day. This might indicate an unfulfilled anticipation of increased volatility, or it may be simply a spurious result. The constraint on index arbitrage is not as economically significant as the anticipation of the constraint.

Price Runs

The 80A amendments may lead to increased price runs. By design, arbitrage maintains market integration by putting counterpressure on diverging prices. If a market becomes thin due to increased uncertainty and a loss of arbitrage-supplied liquidity, then broad liquidity measures, such as market depth, may show significant decreases. Market depth may be examined by analyzing price runs. Holding all else constant, an increase in price runs indicates that the market is thin, or less liquid, at each price. The number of consecutive price changes before a reversal, referred to as "run ticks," and the change in price over a run, referred to as "run length," are examined. If price is only bouncing between the bid and ask, then the mean run length would be equal to the mean absolute price change, which would be equal to the bid–ask spread. If price is a random walk, with only minimum price change moves, then the mean run length would be 0.10. If, however, there is a tendency for price to step up and down the market offer and bid curves, then the mean run length will be a proxy for the distance between the extrema of the bid and offer curves. In this sense, price runs are a proxy for market depth rather than liquidity.

Table V
ABSOLUTE PRICE CHANGE, VELOCITY, AND RULE 80A

Mean absolute price change $= \frac{1}{k}\sum_{i=1}^{k}|\Delta P_i|$; **Mean price velocity** $= \frac{1}{k}\sum_{i=1}^{k}\frac{|\Delta P_i|}{\Delta t_i}$

	Mean Absolute Price Change		Mean Price Velocity	
Variable	**50-Point Effect**	**80A Effect**	**50-Point Effect**	**80A Effect**
Time = $(t - 30)$	0.0067	−0.0025	0.0008	0.0012
	(0.516)	(−0.169)	(0.325)	(0.446)
Time = $(t - 25)$	0.0031	0.0007	0.0019	0.0002
	(0.240)	(0.045)	(0.839)	(0.090)
Time = $(t - 20)$	0.0052	0.0036	0.0020	0.0011
	(0.396)	(0.242)	(0.856)	(0.409)
Time = $(t - 15)$	0.0001	0.0054	−0.0009	0.0029
	(0.006)	(0.369)	(−0.379)	(1.105)
Time = $(t - 10)$	−0.0048	0.0177	0.0002	0.0021
	(−0.415)	(1.301)	(0.100)	(0.886)
Time = $(t - 5)$	0.0052	0.0435	0.0031	0.0043
	(0.447)	(3.252)	(1.499)	(1.798)
Time = (t)	0.0110	0.0358	0.0050	0.0020
	(0.849)	(2.458)	(2.175)	(0.756)
Time = $(t + 5)$	0.0067	0.0336	0.0037	0.0018
	(0.515)	(2.314)	(1.597)	(0.710)
Time = $(t + 10)$	0.0071	0.0239	0.0049	0.0023
	(0.547)	(1.659)	(2.119)	(0.888)
Time = $(t + 15)$	0.0080	0.0067	0.0011	0.0016
	(0.618)	(0.467)	(0.457)	(0.613)
Time = $(t + 20)$	0.0023	0.0080	0.0022	−0.0000
	(0.180)	(0.553)	(0.942)	(−0.004)
Time = $(t + 25)$	0.0010	0.0250	0.0004	0.0045
	(0.079)	(1.726)	(0.154)	(1.743)
Before 50 point	−0.0073	—	−0.0012	—
	(−3.225)		(−3.098)	
After 50 point	−0.0013	—	0.0012	—
	(−0.701)		(3.478)	
Before 80A	—	0.0072	—	0.0016
		(2.993)		(3.797)
After 80A	—	0.0161	—	0.0015
		(7.552)		(3.835)
Midday	0.0631		0.0105	
	(113.802)		(106.384)	
Post-5-point limit	0.1042		0.0154	
	(22.039)		(18.244)	
F-test for significance	$F = 6.8331$		$F = 2.8469$	
of 80A variables	$P = 0.0001$		$P = 0.0003$	

Notes: t-Statistics in parentheses; 50-point variables include both pre- and postamendment data. 80A variables represent incremental effect of 80A. Before and after 50-point (80A) covers the parts of the day not in the half-hour before and after the DOW hits 50 points. Time is measured in five-minute intervals. 80A parameter estimates are incremental effects of 80A.

The mean run length is bounded below by the mean absolute price change (the extreme bid–ask bounce case). Using the price changes from time and sales data, mean run ticks and mean run length are calculated over five-minute intervals.

The mean run length over interval τ is given by:

$$R_\tau = \frac{1}{k}\sum_{i=1}^{k} |\Delta P_{i_x}| \tag{12}$$

where: ΔP_{i_x} = change in price over the run, and k = the number of price runs in interval τ.

There are mixed results regarding the relationship of 80A and price runs as presented in Table VI. The MIDDAY mean run length is 0.1445. This number is about double the mean absolute price change, suggesting that the S&P 500 index futures has bid and offer curves rather than bid and ask prices. As measured by the mean run ticks, the 80A variables are jointly significant. In fact this measure shows a significant decrease which mostly cancels out any 50-point effect. However, in observing the mean run length, the 80A variables are jointly insignificant. For example, suppose that when the bid–ask widens to 10 or 20 minimum price changes (anecdotal evidence suggests quoted bid–ask spreads of 0.5 or 1.00 S&P points during volatile times), there are fewer continuations. In such a situation, mean run length would increase while mean run ticks would decrease.

Daily Tests

In addition to analyzing the side effects of the index arbitrage constraint through regression analysis, the behavior of the side effect measures on individual days are examined. By examining the behavior of these intraday measures for individual days, allowance is made for the heterogeneity of trading days. The average velocity, mean absolute price change, and mean run length measures calculated for one-minute intervals during the trading day are analyzed. To control for any time of the day effects which may exist, an estimate is made of the pattern for the several measures on non-80A days in August, September, and October 1990. For 80A days, the raw measures are adjusted by subtracting the estimated time-of-day effect. The nonparametric Kruskal–Wallis[14] test is then used to test whether the median value of the adjusted measure is the same during an interval before and after the triggering of the 80A rule.[15]

The results from these tests indicate that the constraint has negligible effects. In some cases, the opposite of the hypothesized effect is found. Tables VII through IX show the median values of the price velocity, mean absolute price change, and mean run length measures, respectively, along with the value of the Kruskal–Wallis statistic for each day in the sample.

On four days, mean absolute price change is found to be significantly different in the pre-80A period relative to the post-80A period. On two of the days, August 23 and October 10, the median mean absolute price change is significantly lower following the implementation of the rule. On five days there is a significant change in price velocity. August 23 shows a significantly lower velocity following the 80A triggering. Runs analysis shows six days with significant changes in the measure. For

[14]The Kruskal–Wallis is a nonparametric test based on rank, and adopts the null hypothesis that all k population distribution functions are identical. See Conover (1980, p. 229–237).

[15]The length of the intervals analyzed depended on the time of day at which the constraint was triggered. In general, a one-hour period before and after the constraint time was considered. However, when the rule went into effect either very early or very late in the trading day, equal intervals whose length was equal to the longest interval which could be constructed was used.

Table VI
PRICE RUNS AND RULE 80A

Mean Run Ticks = Average consecutive same sign price changes
Mean Absolute Run Length = Average ($|F_t - F_{t-k}|$), no reversal from $t-k$ to t

	Mean Run Ticks		Mean Run Length	
Variable	**50-Point Effect**	**80A Effect**	**50-Point Effect**	**80A Effect**
Time = (t − 30)	1.8937	−1.6020	0.1347	−0.1036
	(5.130)	(−3.832)	(2.811)	(−1.909)
Time = (t − 25)	0.1708	0.2437	0.0194	0.0226
	(0.464)	(0.584)	(0.406)	(0.418)
Time = (t − 20)	0.1820	0.2583	0.0207	0.0316
	(0.494)	(0.619)	(0.433)	(0.583)
Time = (t − 15)	0.1174	0.1834	0.0001	0.0422
	(0.319)	(0.440)	(0.003)	(0.778)
Time = (t − 10)	0.8152	−0.3644	0.1277	−0.0655
	(2.469)	(−0.949)	(2.980)	(−1.314)
Time = (t − 5)	1.2278	−0.7240	0.1044	0.0364
	(3.719)	(−1.913)	(2.435)	(0.740)
Time = (t)	0.5522	0.3083	0.0709	0.1036
	(1.499)	(0.748)	(1.482)	(1.937)
Time = (t + 5)	0.2695	0.2425	0.0318	0.0931
	(0.732)	(0.591)	(0.665)	(1.747)
Time = (t + 10)	0.3710	−0.1797	0.0455	0.0416
	(1.007)	(−0.440)	(0.952)	(0.785)
Time = (t + 15)	1.0644	−0.7460	0.0992	−0.0380
	(2.890)	(−1.826)	(2.074)	(−0.717)
Time = (t + 20)	0.0104	0.1487	0.0108	0.0324
	(0.028)	(0.364)	(0.225)	(0.610)
Time = (t + 25)	0.0607	0.5647	0.0091	0.0877
	(0.165)	(1.378)	(0.190)	(1.649)
Before 50 point	−0.0262	—	0.0082	—
	(−0.410)		(0.987)	
After 50 point	0.5589	—	0.0292	—
	(10.262)		(4.122)	
Before 80A	—	0.0349	—	−0.0059
		(0.511)		(−0.663)
After 80A	—	−0.4083	—	0.0159
		(−6.762)		(2.023)
Midday	2.3019		0.1445	
	(146.625)		(70.893)	
Post-5-point limit	−0.2476		0.1836	
	(−1.850)		(10.567)	
F-test for significance of 80A variables	F = 5.1891 P = 0.0001		F = 1.6086 P = 0.0690	

Notes: t-Statistics in parentheses; 50 point variables include both pre- and postamendment data. 80A variables represent incremental effect of 80A. Before and after 50-point (80A) covers the parts of the day not in the half-hour before and after the Dow hits 50 points. Means are taken in five-minute intervals. Estimates of 80A parameters are incremental effects.

Table VII
ADJUSTED MEAN ABSOLUTE PRICE CHANGE AND RULE 80A
(AUGUST–OCTOBER 1990)[a]

Kruskal–Wallis Test Statistics for Differences in Median Values

Date	Before/After	Obs.	Median Change	Test Statistic
August 3	Before	17	0.0233	
	After	20	0.0657	0.27
August 10	Before	60	−0.0429	
	After	60	−0.0443	0.03
August 16	Before	18	−0.0406	
	After	33	−0.0229	4.52[c]
August 17	Before	60	−0.0367	
	After	60	−0.0364	0.04
August 21	Before	13	0.0625	
	After	19	0.0155	1.65
August 21	Before	60	−0.0385	
	After	60	−0.0379	0.15
August 23	Before	11	0.1652	
	After	24	0.0369	5.84[c]
August 24	Before	25	−0.0420	
	After	26	−0.0257	2.63
August 30	Before	25	−0.0364	
	After	26	−0.0439	0.92
September 20	Before	39	−0.0393	
	After	39	−0.0456	0.13
September 24	Before	60	−0.0291	
	After	60	−0.0208	1.61
September 27	Before	60	−0.0313	
	After	60	−0.0220	0.03
October 1	Before	60	−0.0297	
	After	60	−0.0384	1.04
October 9	Before	60	−0.0360	
	After	60	−0.0206	10.05[c]
October 10	Before	34	0.0087	
	After	34	−0.0164	3.38[b]
October 11	Before	60	0.0005	
	After	60	−0.0096	0.02
October 18	Before	60	−0.0401	
	After	60	−0.0394	0.26
October 19	Before	32	−0.0300	
	After	32	−0.0301	0.47

[a] Three days, August 6, August 27, and October 5, were dropped from the analysis, since a minimum of 10 observations in either the before or after period could not be achieved.
[b] 90% significance.
[c] 95% significance.

Table VIII
ADJUSTED MEAN PRICE VELOCITY AND RULE 80A
(AUGUST–OCTOBER 1990)[a]

Kruskal–Wallis Test Statistics for Differences in Median Values

Date	Before/After	Obs.	Median Velocity	Test Statistic
August 3	Before	17	0.0488	
	After	20	0.0898	0.58
August 10	Before	60	−0.0138	
	After	60	−0.0174	1.19
August 16	Before	32	−0.0190	
	After	33	0.0096	8.26[c]
August 17	Before	60	−0.0086	
	After	60	−0.0029	1.32
August 21	Before	13	0.0775	
	After	19	0.0477	1.56
August 21	Before	60	−0.0035	
	After	60	−0.0056	0.23
August 23	Before	11	0.1953	
	After	24	0.0591	6.91[c]
August 24	Before	25	−0.0161	
	After	26	0.0040	3.07[b]
August 30	Before	25	−0.0120	
	After	26	−0.0111	0.13
September 20	Before	39	−0.0193	
	After	39	−0.0150	0.51
September 24	Before	60	−0.0069	
	After	60	0.0090	4.98[c]
September 27	Before	60	−0.0027	
	After	60	0.0074	0.05
October 1	Before	60	−0.0009	
	After	60	−0.0068	0.14
October 9	Before	60	−0.0080	
	After	60	0.0016	3.81[b]
October 10	Before	34	0.0334	
	After	34	0.0130	0.92
October 11	Before	60	0.0315	
	After	60	0.0194	0.36
October 18	Before	60	−0.0109	
	After	60	−0.0074	1.64
October 19	Before	32	−0.0038	
	After	32	−0.0006	0.06

[a] Three days, August 6, August 27, and October 5, were dropped from the analysis, since a minimum of 10 observations in either the before or after period could not be achieved.
[b] 90% significance.
[c] 95% significance.

Table IX
ADJUSTED MEAN RUN LENGTH AND RULE 80A
(AUGUST–OCTOBER 1990)[a]

Kruskal–Wallis Test Statistics for Differences in Median Values

Date	Before/After	Obs.	Median Change	Statistic
August 3	Before	17	0.3039	
	After	20	0.5562	2.05
August 10	Before	59	−0.0254	
	After	59	−0.0115	3.26[b]
August 16	Before	30	−0.0321	
	After	32	0.0451	11.14[c]
August 17	Before	59	0.0135	
	After	59	0.0147	0.35
August 21	Before	12	0.2460	
	After	18	0.1681	0.87
August 21	Before	57	0.0486	
	After	55	0.0357	0.14
August 23	Before	11	0.8439	
	After	23	0.3000	16.25[c]
August 24	Before	25	0.0343	
	After	26	−0.0097	2.88[b]
August 30	Before	24	−0.0019	
	After	25	−0.0240	0.92
September 20	Before	35	−0.0002	
	After	39	−0.0071	0.00
September 24	Before	55	0.0231	
	After	58	0.0567	0.38
September 27	Before	57	0.0542	
	After	59	0.0096	8.23[c]
October 1	Before	59	0.0116	
	After	54	0.0231	0.18
October 9	Before	59	0.0191	
	After	57	0.0454	0.47
October 10	Before	33	0.1581	
	After	33	0.0731	2.98[b]
October 11	Before	59	0.1108	
	After	58	0.1189	0.28
October 18	Before	59	0.0003	
	After	57	0.0044	1.47
October 19	Before	32	0.0113	
	After	32	−0.0120	2.46

[a] Three days, August 6, August 27, and October 5, were dropped from the analysis, since a minimum of 10 observations in either the before or after period could not be achieved.

[b] 90% significance.

[c] 95% significance.

two of the days, August 10 and 16, the average absolute price change over a run increases after imposition of the rule; For the other four days, August 23 and 24, September 27, and October 10, the average run length decreases.

CONCLUSIONS

This study considers two hypotheses. First, that the triggering of 80A delinks the S&P 500 index futures and the underlying S&P 500 cash index. Second, that the triggering of 80A leads to harmful side effects, especially in the S&P 500 index futures market. Conclusive evidence is not found to support either hypothesis. It is found that 80A events tend to be unique. Half of the 80A days exhibit basis stability, while on the remaining days the basis seems to become unstable. Instability is found also in the basis on 50-point days earlier in 1990, when arbitrage was not constrained by regulation. There appears to be an inverse relationship between market-wide volatility and basis stability, and it would be unwise to attribute the basis instability found on 80A days to triggering of the rule, rather than the extant increased volatility. Therefore, 80A does not appear to be unduly constraining index arbitrage.[16] Some firms may, for strategic reasons, normally transact with tick-sensitive orders. When 80A is triggered, and if strategies are not altered, then index arbitrage volume becomes a fraction of its normal level. This study suggests that either (1) the traders who normally transact tick-sensitive index arbitrage (assuming they exist)[17] increase their activity on the 80A days; or (2) other traders begin tick-sensitive arbitrage on the 80A days. Either scenario leads to less than segregated markets.

Overwhelming evidence of appreciable harm is not found to be caused by the constraint on index arbitrage triggered by the Dow moving 50 points from the previous trading day's close. Volatility, liquidity, and depth are affected to a minor degree by the triggering of 80A, but no harm to the marketmaking sector is found.

Failure to find consistently significant effects associated with the triggering of NYSE Rule 80A suggests a broader framework of analysis such as an examination of political and rent-seeking motivations behind index and index-derivative trading regulation. The documentation surrounding 80A does not analyze winners and losers associated with the passage of the amendments to 80A. Perhaps such a comparative analysis would be a more fruitful approach to the investigation of the effects of 80A. The avowed decreased price volatility and/or market delinkage arguments appear unsubstantiated. However, the failure to find significant 80A effects is not meant to preclude their existence. The conclusions reached here are limited by the small number of 80A events and the power of the tests.

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[16]The New York Stock Exchange (1991) reports that when 80A is triggered, the volume of index arbitrage is lower than might be expected, given that the DOW has moved 50 points. When the market has fallen 50 points sell index arbitrage is off by around 33% relative to 50-point days without the 80A restriction.

[17]In a series of interviews done jointly by the SEC and CFTC staff with index arbitragers in November 1989 several firms revealed that their general arbitrage strategies included tick-sensitive trading. The New York Stock Exchange (1991) reports that it is the principals (broker-dealers) who continue to perform index arbitrage, while index arbitrage by customers dries up.

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