Nasdaq's Closing Cross

Has its new call auction given Nasdaq better closing prices?

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On March 29, 2004, the Nasdaq stock market expanded its hybrid market structure by introducing a price discovery call auction. The call is run daily at 4:00 PM to close the normal Nasdaq trading day. Nasdaq refers to this as a "closing cross," but the facility is in fact a call auction because it provides price discovery.[1]

We assess the impact of the call on Nasdaq's official closing prices. Our assessment should be considered preliminary, because relatively little time has passed since the call was instituted. Time is required for participants to learn how best to use any new system, and for sufficient data to be generated for a more complete analysis. Nevertheless, we have undertaken this early assessment in view of the importance of the innovation.

A call auction differs from continuous trading. In a *continuous market*, a trade is made whenever a bid and offer match or cross each other in price. In a *call auction*, buy and sell orders are cumulated for each stock for simultaneous execution in a multilateral and batched trade, at a single price, at a predetermined time. By consolidating liquidity at specific times, a call auction is intended to reduce execution costs for individual participants, and to sharpen the accuracy of price discovery for the broad market.[2]

Call auctions have historically been a standard part of the French and German exchanges. The Deutsche Börse holds three calls a day for its large-market capitalization stocks. Closing call auctions were introduced in Europe specifically because of customer demands for

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improved price discovery at market closings. Most important, trading in derivatives such as equity options can be adversely affected when only a small number of orders can cause price dislocations in the equity market (the motivation for introducing the closing calls, according to senior officials at the Paris Bourse). It can be difficult for traders to unwind their positions, and for positions to be marked to market at appropriate prices.

Indexers have their own needs to trade with certainty and precision at the closing prices that are used to compute the index values that they are seeking to track. It is difficult to do this on days firms are added to and dropped from an index. Blume and Edelen [2004, p. 41], in research that predates Nasdaq's closing cross, note that "Nasdaq has no formal mechanism to assure that a non-prearranged trade would take place at the closing price." The formal mechanism that would give this assurance is a closing call auction.[3]

Fully electronic call auctions have long been the standard procedure for opening the electronic order book markets of Canada, Europe, and the Far East (see Schwartz and Francioni [2004]). Until recently, they have been neither widely used nor well understood in the United States. The New York Stock Exchange opens and informally closes with calls that are not fully electronic, and, until its introduction of an opening call in the fall of 2004, Nasdaq has had no special opening facility at all.

Because of the importance of a single-price opening procedure, Arthur Levitt, then chairman of the U.S. Securities and Exchange Commission, pressured Nasdaq in May 2000 to introduce call auction trading.[4] Nasdaq responded by establishing a special committee to consider the procedure, but the committee ended its work with no plans to introduce a call into its market model.

At the time, introduction of a periodic, batched auction into Nasdaq's sequential execution system would have presented a formidable challenge (as we learned from Frank Hatheway). Subsequently, the introduction of SuperMontage in Summer 2002 made the prospect of running a price discovery auction feasible, and Nasdaq's incentive to proceed with the innovation intensified in the Fall of 2003 when the American Stock Exchange, responding to Standard & Poor's expressed desire for better closing prices, announced it would introduce a closing call auction.[5]

The Amex call started as a pilot program in December 2003. Nasdaq's closing cross began operation on March 29, 2004.

Any market structure change can leave difficult-to-detect footprints in the data, given the myriad of factors that impact security prices. Detection at this time would be especially difficult with regard to Nasdaq's introduction of the closing cross. For one thing, the time series data available for the analysis are limited. More important, participants have had very little time to become accustomed to the new facility and to establish their procedures for responding to imbalance information. The closing cross is a major change in the Nasdaq market, nonetheless, and an attempt to assess its impact carries with it an effort to better understand the innovation.

Our assessment focuses on the impact of the closing cross on price determination at the June 25, 2004, Russell 2000 index rebalancing. Because of the importance of the Russell rebalancing, Nasdaq had accelerated its rollout of closing cross so that all of the almost 1,700 Nasdaq stocks in the index would be in it by June 25. This move led Sofianos and Su [2004b, p. 1] to write:

> it will take time and experience for Nasdaq to fine-tune its Closing Cross and for all market participants to fully incorporate it in their trading routines and systems. The Russell rebalancing is happening too soon, before Nasdaq had the chance to gradually build full confidence in its new closing procedures for such a large number of stocks.

Key features of closing cross are the transparency it provides and the opportunity participants have to enter imbalance orders. But these features will work only if enough participants are watching the screens and entering these orders. Sofianos and Su [2004b, p. 2] further wrote:

> On June 25, many passive indexers will be demanding liquidity in the same direction. This will cause large imbalance announcements and profit opportunities for liquidity suppliers. The Nasdaq Closing Cross will make it easier for liquidity suppliers to identify these opportunities and provide liquidity, reducing closing price dislocation.

Then the authors added a caveat: "The imbalance announcements will not work if nobody is watching."

In Pagano and Schwartz [2003], we assess the impact on price determination at the close that attended the Paris Bourse's inclusion of electronic call auctions at market closings in 1996 (for one set of stocks) and in 1998 (for a second set of stocks). The findings yielded by our

Paris study indicate that the innovation significantly improved market quality at closings, and that the new procedure is a good complement to the electronic call auction openings.

We use a similar methodology here. We use the well-known market model to analyze the relationships between returns on individual stocks and the returns on a market index. Various researchers have found that the relationship between stock and index returns becomes much fuzzier when short-run returns (e.g., daily) are used in place of longer-run returns (e.g., monthly) (see, for example, Fisher [1966] for early work in this area, as well as Cohen et al. [1983a, 1983b]). This deterioration has been attributed to price dislocations and other sources of noise in the price discovery process. Accordingly, any sharpening of price discovery following the introduction of the closing call should mean we can obtain more accurate market model estimates from daily data.

Extensive calendar data are needed, however, to compare market model estimates obtained using short return intervals with estimates obtained using long intervals, and relatively little time has passed since Nasdaq instituted its closing cross. We overcome this problem by using market model parameters estimated from prior data, and by focusing on two days the market closing was under particular stress: the annual Russell 2000 index rebalancing on June 30, 2003, and the Russell rebalancing on June 25, 2004. We also analyze price determination on several surrounding days (one trading day before and after, and seven trading days before and after, each of the two rebalancing days).

DESCRIPTION OF CROSS PROCESS

Nasdaq's closing cross is an intricate facility that includes new types of orders; new order handling, display, and price determination procedures; and safeguards against unduly large price changes. But its fundamental functionality is straightforward.[6]

The key to Nasdaq's closing cross is the interaction of its continuous market with three types of close-specific orders: market-on-close (MOC) orders, limit-on-close (LOC) orders, and imbalance orders (IO). The MOC and LOC orders are standard market and limit orders, except that they are to be executed in the closing cross only. These on-close orders can be entered or cancelled at any time from the market's 9:30 AM opening until 3:50 PM, ten minutes before the market's close.

At 3:30 PM, the facility starts accepting imbalance orders. As the term implies, IOs are designed to reduce any imbalances there may be between the market orders and limit orders that have been entered for the cross. All IOs must be priced. An IO sell is executable only if it is priced at or above the 4:00 PM Nasdaq offer, and an IO buy is executable only if it is priced at or below the 4:00 PM Nasdaq bid.[7]

Because they are prevented from being priced aggressively, IOs will never trade against each other. Rather, IO sells will execute against any buy imbalance (that drives price up), and IO buys will execute against any sell imbalance (that drives price down). IOs can be entered until the time of the cross but, like the MOC and LOC orders, cannot be cancelled after 3:50 PM.

Transparency is critical. The driving force behind good price discovery at the close is for participants to see any buy or sell imbalances, and to benefit from an imbalance by entering an order that offsets it. Accordingly, between 3:50 PM and 4:00 PM, Nasdaq disseminates information about imbalances, indicative clearing prices, and the number of on-close and IO shares that the market is able to match at an indicative clearing price as the close approaches.

The frequency of information dissemination increases from every 30 seconds (starting at 3:50), to every 15 seconds (at 3:55), to every 5 seconds (at 3:59). In total, users have ten minutes to check 1,500 issues for order imbalances and to respond. Order entry mistakes and the infeasibility of taking multiple looks at a stock will limit the effectiveness of closing cross until appropriate order management systems for doing this electronically are put in place.

At 4:00 PM, no further orders are accepted, and determination of the closing prices begins. At the cross, the MOC, LOC, and imbalance orders are brought together, along with limit orders and quotes from SuperMontage. A fairly complex algorithm is then used to determine the clearing price and the specific orders that trade.

The first criterion used for selecting the clearing price is to maximize the number of shares that will trade at the cross.[8] Time and price priorities are used to determine the specific orders that execute, given the clearing price. In the determination, MOC orders receive the highest priority, which makes them highly likely to execute, although execution is not guaranteed.

In general, buy orders at the clearing price and higher execute, as do sell orders at the clearing price and lower. All the executed orders for a stock clear at a single price. Because of the transparency of the system, the pooling of all orders for a stock, and inclusion of imbal-

ance-only orders, these single-price auctions are expected to generate values that are less subject to price dislocations and are more in tune with the broad market's demand to hold shares.[9]

Closing cross has been stress-tested at various rebalancings and expiration days since its introduction. Both the event days and the surrounding days are stressful, as participants preposition and postposition their holdings. Executives at Nasdaq have found that, by and large, the new facility has been adequate to the task from technical, user, and broader economic perspectives. Complexity does not appear to have been a drawback; heavy volumes have been adequately handled; and closing price behavior has seemingly improved.

The biggest test thus far for closing cross was on June 25, 2004, the day of the Russell 2000 rebalancing. 1,637 Nasdaq stocks participated in the rebalancing. Aggregate trading volume on that day was 2.54 billion shares, a total exceeding Nasdaq's average daily trading volume by roughly 72%. Of the 2.54 billion shares, 333.39 million (13.14%) were in the cross.[10]

The median price difference between the volume-weighted average price (VWAP) for the five-second interval preceding the cross and the price set at the cross was 16 cents (roughly 1.0% of price). Our analysis suggests that this average pricing difference might, in part at least, be mitigating the dislocations experienced in the continuous market at this stressful time.

METHOD FOR ASSESSING MARKET QUALITY

Our assessment of the closing call's impact is based on a methodology that we used for the Paris study (Pagano and Schwartz [2003]). The key to the methodology is recognition that inaccuracies in price discovery for individual stocks are reflected in non-synchronous price adjustments across stocks and that, because of this, we can gain insight into price discovery by studying the comovement of security prices in relatively brief intervals of time (i.e., one day). That is, our procedure enables us to infer market quality from the synchronicity of price changes across a set of stocks.

Toward this end, we use the well-known market model to infer the quality of price discovery at market closings. The market model simply regresses a company's stock returns on the returns for a market portfolio using the equation:

$$\kappa_{j,t} = \alpha_j + \beta_j \kappa_{m,t} + \varepsilon_{j,t} \qquad (1)$$

where

$\kappa_{j,t}$ = daily stock return for company j at time t;
α_j = intercept term;
β_j = measure of the j-th stock's sensitivity to the systematic market risk factor;
$\kappa_{m,t}$ = daily stock return on the systematic risk factor, i.e., the "market" return at time t; and
$\varepsilon_{j,t}$ = random error term (market model residual) at time t with zero mean.

Drawing on Cohen et al. [1983a, 1983b], we use the market model to contrast the short-run and long-run relations between individual stock returns and broad market index returns. Factors such as bid-ask spreads, market impact, and inaccuracies in price discovery all affect the very short interval returns (i.e., daily). More important, short-term stock price adjustments across a set of stocks are expected to be non-synchronous if price discovery for individual equity shares is a protracted process (as the research suggests).

Our methodology is designed to capture this non-synchronicity. The key is observing the extent to which residual variance (the variance of the $\varepsilon_{j,t}$) is higher when returns are measured using a daily interval in place of a longer interval (e.g., one month). We assess residual variance by examining its converse, the square of the market model correlation coefficient, R^2, a statistic that measures the percentage of variation in the dependent variable ($\kappa_{j,t}$) that is explained by variation in the independent variable, $\kappa_{m,t}$. Higher values of R^2 indicate that a stock's price movements are more closely aligned with changes in the broad market.

This methodology provides the basis for our study of the introduction of the closing call in the Paris market. The Paris Bourse (now known as Euronext Paris) provided an exceptionally rigorous environment for assessing the efficiency of call auction trading. Because the Bourse introduced its closing call at two different dates for two different sets of companies, we were able to test the robustness of our analysis through replication. In addition, we contrasted changes in the quality of the market at closings with changes in the quality of the Paris Bourse's market openings.

This gave us reasonable assurance that our findings were not attributable to the particular time period used or to the specific sample of stocks selected. We have some confidence that our statistical findings are attributable to the call itself, not to some other factor.

The Paris study, however, required a rather extensive set of calendar data. We used 500 trading days' worth

of data to estimate the requisite market model parameters spanning the periods May 1995–April 1997 and June 1997–May 1999 for the two closing call event dates. A similar test design for our current Nasdaq study would have required a data set that extended to June 2005. We expedite the estimation process by using a modified methodology to focus on just a few days of particular stress, at and around the days of the Russell 2000 index rebalancing in 2003 and in 2004.

Amihud, Mendelson, and Lauterbach [1997] describe a relative return dispersion (RRD) measure that can be computed using the residuals from a market model. Using the market model run on daily data, the statistic is calculated for day t as:

$$\mathrm{RRD}_t = \Sigma_j \varepsilon_{jt}^2 / n \qquad (2)$$

where RRD_t is the relative return dispersion for the entire sample of securities on day t; ε_{jt}^2 is the squared market model residual for security j at time t; and n is the number of securities in the sample on day t.

The relative return dispersion measure incorporates market frictions from a different perspective from the conventional market model R^2 statistic. The R^2 statistic captures the size of market model residuals over time for a particular stock. Amihud, Mendelson, and Lauterbach's RRD measure depicts the size of the market model residuals across stocks for a particular trading day. The two measures provide complementary methods for examining marketwide changes in trading costs and the accuracy of price determination.

The RRDs should be higher on days the market faces large buy or sell order imbalances but, for any given level of stress, lower if the trading system is better able to cope with these imbalances. For this reason, the measure is particularly suitable for analyzing the quality of price determination at Russell index rebalancings (days of particular stress), and for contrasting the 2003 rebalancing (before closing cross was introduced) with the 2004 rebalancing (with closing cross). If the new facility has in fact made price determination more accurate, price adjustments across stocks should be more synchronous, and the RRD statistic for the 2004 rebalancing should be lower than it was for the 2003 rebalancing.

ANALYSIS OF THE PARIS CLOSING CALL

Our analysis of price behavior at the Paris Bourse is based on two samples of firms (50 relatively small-cap B stocks, and 50 large-cap A stocks) for two different event dates (the closing call was introduced on May 13, 1996, for the B stocks, and on June 2, 1998, for the A stocks). Our market model tests indicated that price adjustments for these stocks were more synchronized after the closing call's implementation. We are confident that the basic methodology can be used to assess the impact of Nasdaq's closing cross.

EXHIBIT 1
Comparison of Adjusted R^2 Statistics—Paris Bourse

	Smaller-Cap Stocks			Larger-Cap Stocks		
Average R^2	Pre-Event	Post-Event	% Diff.	Pre-Event	Post-Event	% Diff.
1-day interval	0.005	0.012	**140.0**	0.101	0.120	18.8
20-day interval	0.050	0.094	88.0	0.177	0.275	55.4
Change in R^2 (20-day minus 1-day)	0.045	0.082	140.0	0.076	0.155	103.9
% Difference	**900.0**	**683.3**		**75.3**	**129.2**	

Boldface identifies the differences between the average R^2 statistics that are significant at the 0.01 level.

Exhibit 1 shows sample average R^2 for the two sets of stocks (the less-liquid, small-cap B shares, and the more-liquid, large-cap A shares), for two measurement intervals of 1 day and 20 days.[11] The individual R^2 display considerable variation across measurement intervals and for the large- and small-cap stocks. Nevertheless, they provide a good overview of the closing call's impact on the synchronicity of price movements across stocks.

For the small-cap B stocks, the pre-event R^2 average 0.050 for the 20-day interval and 0.005 for the 1-day interval, a 900% difference. The comparable values for the large-cap A stocks are 0.177 for the 20-day interval and 0.101 for the 1-day interval, a 75.3% difference. After the event dates, the across-firm average one-day R^2 increase 140% for the B stocks and 19% for the A stocks. The jump is very clear for the small-cap stocks but less so for the large-caps, especially given the underlying variability in the R^2 measurements.

We further find that improving market quality at the close had broader impacts on the Paris market. Spreads tightened during the final hour of trading in the Bourse's continuous B market (not tabulated here). Presumably, knowing that they could always go into the closing call, traders were more willing to place limit orders and to run the risk of not executing in the closing minutes of the continuous market. Further, the quality of price formation

EXHIBIT 2

Comparison of Adjusted R^2 Statistics—2000–2003 at Nasdaq

Average R^2	Earlier	Later	% Diff.
1-day interval	0.074	0.157	**112.2**
20-day interval	0.100	0.134	34.0
Change in R^2 (20-day minus 1-day)	0.026	-0.023	n.m.
% Difference	35.1	-14.6	

Boldface identifies the differences between the earlier and later periods' average R^2 statistics that are significant at the 0.01 level. n.m. denotes not meaningful.

improved at next-day openings (although not as much as at the close itself). Apparently, sharpened price formation at the close has a positive spillover that translates into more accurate price determination at next-day openings.

The results for the Paris study are consistent for two independent events that involved two different samples of stocks and that occurred on two different dates. They are also robust to the possible confounding effects of samplewide changes in return volatility and trading volume during the periods surrounding the closing call's two implementation dates. Our findings are further supported by the lack of any material changes in the test statistics for two control samples for both opening and closing prices. This gives us further confidence that our results are not attributable to the specific samples of stocks or time periods, or to the methodology.

MARKET MODEL RESULTS FOR NASDAQ STOCKS

We run a comparable market model test on 50 Nasdaq stocks for the periods January 2000–December 2001 and January 2002–December 2003. Our objective is to assess changes in the market model R^2 statistic for the Nasdaq stocks as we switch from a 20-day to a 1-day measurement interval. We want to determine whether non-synchronicity characterizes daily closing prices in the Nasdaq market as it does in the Paris market.

Our two Nasdaq samples capture two different sets of market conditions. During 2000-2001, the stock market bubble burst, and the U.S. economy entered its first recession in over a decade (March 2001–November 2001, per the National Bureau of Economic Research cycle dating methodology). In the following period, 2002–2003, macroeconomic growth rebounded and, as it did, the market bottomed out and rallied strongly.

We apply the methodology in Pagano and Schwartz [2003] to a stratified sample of 50 Nasdaq stocks using daily closing prices. The sample includes the 10 most actively traded Nasdaq stocks for 2003 plus 40 stocks randomly selected from size-ranked deciles (four stocks from each of the ten market capitalization deciles created by the Center for Research in Security Prices).

We then run market model regressions for each stock for 12 different return intervals (1 – 10, 15, and 20 days). These 600 regressions (50 stocks × 12 intervals) are estimated for both sample periods (2000–2001 and 2002–2003). This yields 1,200 regressions in total (600 × 2 periods). For the most part, the results for R^2 are similar in size to those reported in Pagano and Schwartz [2003].[12]

Exhibit 2 shows the R^2 values for two of the measurement intervals (1-day and 20-day) and for the two time periods. For the earlier period, R^2 increases 35.1% (from 0.074 to 0.100) as we move from the 1-day interval to the 20-day interval. Surprisingly, in the later period, the average R^2 is actually higher for the 1-day interval than for the 20-day interval, although the two values are virtually identical (0.134 and 0.157 for the 20-day and 1-day intervals, respectively). Apparently, the rapidly rising tide of the market during the rebound period carried a broad array of Nasdaq stocks along with it on a daily basis.

RUSSELL REBALANCING

The 1996 and 1998 results for the Paris Bourse stocks, coupled with the 2000–2003 evidence for the Nasdaq stocks, suggest that market frictions perturb the synchronicity of intraday price movements, and that introduction of a closing call auction has the potential to improve market quality for Nasdaq. To test this hypothesis, we examine some of the most stressful trading days of the year on Nasdaq, the days surrounding the Russell 2000 index rebalancing.

Our test focuses on the relative return dispersion statistic described by Equation (2). If the closing cross has had a beneficial effect, RRD should be *lower* during the 2004 rebalancing than the 2003 rebalancing. This is a tough test, given that the 2004 rebalancing occurred only three months after introduction of the closing cross. Sofianos and Su [2004b, p. 2], writing before the rebalancing, put it this way: "but on June 25, traders will be stress testing a complicated closing mechanism that has been up and running for only a few months."

Over the next several years, more extensive time

series data will be available and, more important, Nasdaq's closing call will have become more familiar to traders and portfolio managers. Nevertheless, a preliminary assessment is possible today.

Rebalancing

The rebalancing of the Russell 2000 index is an annual event that has taken place toward the end of June each year since 1990.[13] The index is composed of small- to mid-cap U.S. stocks, and the rebalancing (or "reconstitution" as Russell calls it) is a stressful event for portfolio managers and Nasdaq, the market where most of the stocks in the index trade. As Russell's website notes, "over $300 billion is invested in funds that rely on Russell's U.S. indexes as investment models" (see www.russell.com).

Russell ranks the largest 3,000 U.S. stocks by their market capitalizations as of the end of May, starting with the largest. The Russell 2000 includes the smaller two-thirds of this set (i.e., stocks ranked 1,001–3,000). The Russell 1000 index represents the top 1,000 U.S. stocks, but portfolio managers generally concentrate more on the Russell 2000, possibly because the large-cap stocks are in other widely tracked indexes such as the S&P 500 and the Dow Jones Industrial Average. Preliminary lists of additions, deletions, and weight changes to the Russell 2000 are circulated during June prior to the official effective date of the index's rebalancing.

Trading is unusually heavy on the rebalancing day and the surrounding days. Portfolio managers sell the stocks that are being dropped from the index or that are being given a reduced weight in it, and buy the stocks that are being added or are to be given a greater weight. Managers who want to minimize tracking error relative to the index typically concentrate their trades on the official rebalancing date and, because one closing price is used to compute two returns, greater return variance (measured using closing prices) may be observed on the day of the rebalancing and on the following day.[14]

The additions to and deletions from the index are announced earlier in June, and some managers choose to adjust their portfolios closer to the announcement date than to the implementation date. We have been told that some managers traded in advance of the 2004 rebalancing for another reason: to guard against the possibility of a technical failure preventing them from executing in closing cross on June 25.

Before 2004, the annual rebalancing occurred on the last trading day of June (typically June 30). In 2004, Russell moved the rebalancing date up to the last Friday in June to allow more time before the next trading day in order to alleviate potential trade processing concerns. In a Russell press release dated February 5, 2004, Sandy Rattray, a managing director at Goldman, Sachs & Co., was quoted as saying:

> The Russell index reconstitution day is one of the busiest trading days in the U.S. equity market, particularly because passive managers are rebalancing small cap portfolios. Occasionally closing prices can be difficult to immediately determine on the rebalance day. Moving the date to the last Friday in June allows exchanges, asset managers and brokers plenty of time to be ready for the next trading day if operational issues arise.

Accordingly, the Russell 2000 rebalancing, which was on June 30 in 2003, was moved to June 25 in 2004. We use these two event dates as the primary focus of our analysis.

Data

For our relative return dispersion tests, we first compute the residuals from the market model described by Equation (1) for the specific event dates in question. These residuals, the $\varepsilon_{j,t}$ (also known as abnormal returns), are squared and averaged across stocks for a specific day (e.g., June 25, 2004, for the 2004 event, and June 30, 2003, for the 2003 event). The cross-sectional average is our RRD statistic.

We compare the RRD for June 30, 2003, with the RRD for June 25, 2004, and we test the hypothesis that Nasdaq's closing call *improved* market quality. For this purpose, we apply difference-in-means statistical tests for the overall sample of stocks, and for quartiles broken down by market capitalization. If the call were successful, we expect, all else equal, that the RRD for 2004 will be lower than the RRD for 2003.

Daily returns are computed using Reuters' *Bridgestation* service for the relevant days surrounding the 2003 and 2004 rebalancings. The assessment covers 1,488 stocks in 2003 and 1,550 stocks in 2004. Along with the daily returns for the individual stocks, market index returns and beta estimates are needed to calculate the market model residuals. For this purpose, we use the daily return on the S&P 500 stock index and the 60-month beta estimates precomputed by Standard & Poor's Compustat service. The

EXHIBIT 3

Relative Return Dispersion (RRD) Test Results

A. 2003 – 2004 Difference in Means Test Results for Full Sample

Variable	2003 Mean	2004 Mean	Difference	Pct. Diff.	t-Value	Pr > |t|
RRD (–7)	**0.000858**	**0.000432**	**-0.000426**	-49.6%	**-5.95**	0.0001
RRD (–1)	**0.000733**	**0.000583**	-0.000150	-20.5%	-1.48	0.1389
RRD (0)	**0.000968**	**0.000842**	-0.000126	-13.0%	-1.26	0.2067
RRD (+1)	**0.000899**	**0.000653**	**-0.000246**	-27.4%	**-3.21**	0.0015
RRD (+7)	**0.000750**	**0.000402**	**-0.000348**	-46.4%	**-4.05**	0.0002
RRD (–1 to +1)	**0.002089**	**0.001673**	**-0.000416**	-19.9%	**-2.06**	0.0401

B. 2003 – 2004 Difference in Means Test Results Ranked by Market Capitalization (First/Smallest Quartile)

Variable	2003 Mean	2004 Mean	Difference	Pct. Diff.	t-Value	Pr > |t|
RRD (–7)	**0.001332**	**0.000417**	**-0.000915**	-68.7%	**-5.49**	0.0001
RRD (–1)	**0.001129**	**0.000709**	**-0.000419**	-37.2%	**-2.12**	0.0347
RRD (0)	**0.002035**	**0.001338**	**-0.000697**	-34.2%	**-2.33**	0.0206
RRD (+1)	**0.001378**	**0.000895**	**-0.000483**	-35.0%	**-2.62**	0.0093
RRD (+7)	**0.001234**	**0.000580**	**-0.000654**	-53.0%	**-3.09**	0.0023
RRD (–1 to +1)	**0.004226**	**0.002492**	**-0.001734**	-41.0%	**-2.97**	0.0033

C. 2003 – 2004 Difference in Means Test Results Ranked by Market Capitalization (Second Quartile)

Variable	2003 Mean	2004 Mean	Difference	Pct. Diff.	t-Value	Pr > |t|
RRD (–7)	**0.000879**	**0.000473**	**-0.000406**	-46.1%	**-3.41**	0.0008
RRD (–1)	**0.000755**	**0.000593**	-0.000162	-21.5%	-1.20	0.2316
RRD (0)	**0.000914**	**0.000842**	-0.000072	-7.9%	-0.54	0.5893
RRD (+1)	**0.001027**	**0.000661**	**-0.000366**	-35.6%	**-2.21**	0.0276
RRD (+7)	**0.000643**	**0.000380**	**-0.000263**	-40.9%	**-2.72**	0.0070
RRD (–1 to +1)	**0.001684**	**0.001493**	-0.000190	-11.3%	-0.83	0.4084

D. 2003 – 2004 Difference in Means Test Results Ranked by Market Capitalization (Third Quartile)

Third Quartile Variable	2003 Mean	2004 Mean	Difference	Pct. Diff.	t-Value	Pr > |t|
RRD (–7)	**0.000736**	**0.000449**	**-0.000287**	-39.0%	**-1.99**	0.0476
RRD (–1)	**0.000664**	**0.000297**	**-0.000367**	-55.3%	**-4.11**	0.0001
RRD (0)	**0.000610**	**0.000673**	0.000063	10.3%	0.39	0.6989
RRD (+1)	**0.000694**	**0.000580**	-0.000115	-16.5%	-0.75	0.4544
RRD (+7)	**0.000779**	**0.000281**	**-0.000498**	-63.9%	**-2.15**	0.0323
RRD (–1 to +1)	**0.001533**	**0.001043**	**-0.000490**	-32.0%	**-2.26**	0.0243

E. 2003 – 2004 Difference in Means Test Results Ranked by Market Capitalization (Fourth/Largest Quartile)

Fourth Quartile Variable	2003 Mean	2004 Mean	Difference	Pct. Diff.	t-Value	Pr > |t|
RRD (–7)	**0.000483**	**0.000388**	-0.000095	-19.8%	-0.70	0.4819
RRD (–1)	**0.000386**	**0.000723**	0.000336	87.1%	1.07	0.2852
RRD (0)	**0.000316**	**0.000476**	0.000160	50.6%	1.16	0.2481
RRD (+1)	**0.000499**	**0.000457**	-0.000042	-8.5%	-0.48	0.6285
RRD (+7)	**0.000346**	**0.000362**	0.000016	4.6%	0.16	0.8765
RRD (–1 to +1)	**0.000917**		0.000681	74.2%	1.56	0.1201

Boldface denotes statistically significant differences from 0 at the 0.05 or lower level.

beta estimates are based on monthly return data for the individual stocks and for the S&P 500 stock index during the 60-month period ending in April of each of the two years.[15]

Using the data described above, we compute the market model residual for each of the stocks for each of the days in our analysis. To examine the immediate effect of the two rebalancings, we calculate the market model residuals and average RRD statistic for the day before the event ($t - 1$ in our notation), the actual day of the rebalancing (t), and the day following the event ($t + 1$). Recognizing that the rebalancing has an even more protracted impact as some managers preposition well before the event while some who have overcompensated subsequently reverse their unbalanced positions, we also compute the market model residuals and RRD statistics for the seventh trading day preceding and the seventh trading day following the 2003 and 2004 events.[16]

In all, we have five RRD statistics for each of the two years: days $t - 7$, $t - 1$, t, $t + 1$, and $t + 7$. The RRD statistics are computed for the full sample of stocks, and for four quartiles that are based on the market capitalization of the stocks as of the end of April for each year.

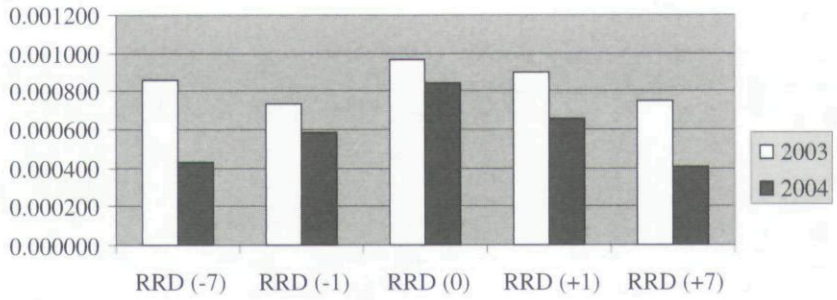
Findings

The RRD statistics are given in Exhibit 3. The first two columns report the cross-sectional means for 2003 and 2004. The actual and percentage differences between these averages are presented in the third and fourth columns, and the last two columns display the related t-statistics and p-values associated with a difference-in-means test. Panel A gives the results for the full sample, and Panels B–E show the results for each of the four market cap quartiles, from the lowest to the highest.[17]

Panel A shows that, for the full sample, the RRD statistics are uniformly

EXHIBIT 4

Relative Return Dispersions for Russell 2000 Rebalancings—2003–2004



lower in 2004 than in 2003. The greatest reductions (in percentage terms) occurred during trading days $t-7$ and $t+7$. The RRD statistics for the three days surrounding the 2004 event are also lower than their 2003 counterparts (e.g., 13% – 27% lower), but only the $t+1$ day difference is statistically significant. The lack of statistical significance on days $t-1$ and t may not be surprising, given the added volatility leading up to and including the official index rebalancing date.

We examine the three days surrounding the event because the Russell 2000 rebalancing appears to create price dislocations for the day before, the day of, and the day after the event, and because, as we have noted, a price dislocation on any day t affects the return computed for days t and $t+1$. For example, increased buying for a stock that is included in the Russell 2000 index could cause a positive price dislocation at the time of the rebalancing (day t) that might be repaired (at least partially) on the following day (day $t+1$). For this reason, we expect RRD to be highest for days t and $t+1$.

Also shown in Panel A of Exhibit 3 is the RRD statistic over the three-day event window [referred to as RRD (–1 to +1). This measure is also significantly lower for 2004 (0.001673 for 2004 versus 0.002089 for 2003, or 19.9% less). The cross-sectional standard deviation of the individual stocks in our sample is 3.1% for the 2003 event day and 3.2% for the 2004 event day, and hence the appreciable decrease in the RRD statistic could not be attributable to an overall difference in the daily return volatility of individual stocks for the two days.[18]

The story told by the RRD statistics is graphed in Exhibit 4. The bars reveal a distinct pattern. The 2004 RRDs for the full sample rise until the rebalancing day, and then decline sharply over the post-event days. The 2003 RRDs display a similar pattern, but are consistently higher than the 2004 values across the five days. The sizable peaks in RRD observed on the official rebalancing days underscore that the 2004 Russell 2000 index rebalancing was indeed a stressful, economically significant event, as was the 2003 event.

The market cap subsets tell a more striking story. The RRD statistics for the four subsamples are reported in Panels B-E of Exhibit 3. Interestingly, the smallest market cap quartile (the first) shows the greatest declines in RRD during the 2004 event. The RRDs for each of the five days are significantly lower in 2004 than in 2003, with declines ranging from 34% on the event day to 69% on day $t-7$. The cumulative decline, for the three-day period –1 to +1, is 41%.

Turning to the second and third quartiles, we see in Panels C and D of Exhibit 3 that the declines in the 2004 RRD statistics during the event window conform to the general pattern described for the first (smallest) quartile stocks, but that the reductions are not as great and are generally less significant than they are for stocks in the first quartile. Panel E shows, for the largest stocks, that the 2004 RRDs actually exceed their 2003 values, although the increases are statistically insignificant. The 2004 RRDs for days –7 and +7 are lower than the comparable 2003 values, but these differences also are not statistically significant.

The average and the median RRDs across the four quartiles are graphed in Exhibits 5 and 6. We report both the means and the medians because the average RRD results could be influenced by outliers (i.e., stocks that might have experienced unusually large price dislocations at the rebalancing). The median RRDs shown in Exhibit 6 conform to our mean RRD findings and, in fact, present clearer support for the hypothesis that the closing cross has sharpened price discovery.

Overall, both graphs show two things: 1) that the smallest-cap stocks experienced the highest RRDs, and 2) that the small-caps benefited the most from closing cross at the 2004 rebalancing. This result, which is consistent with our findings for the Paris study, is quite plausible—the small, illiquid stocks are most likely to experience price dislocations when under stress, and the Russell rebalancing is especially stressful for the small-cap stocks (stocks that are added to the index are generally small, as are the fallen angels that are dropped). The large-cap stocks are basically unaffected by the reweightings.

EXHIBIT 5

Average Relative Return Dispersion Estimates for Size-Based Quartiles

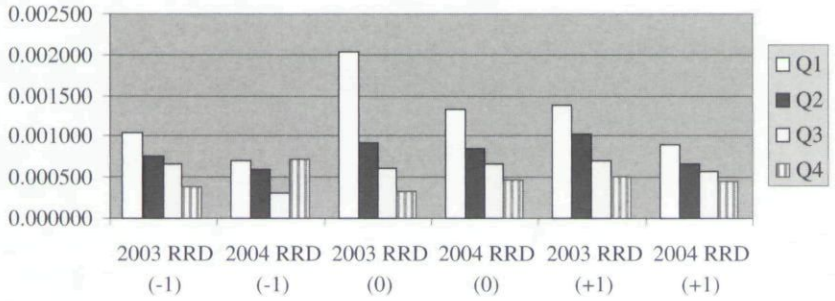
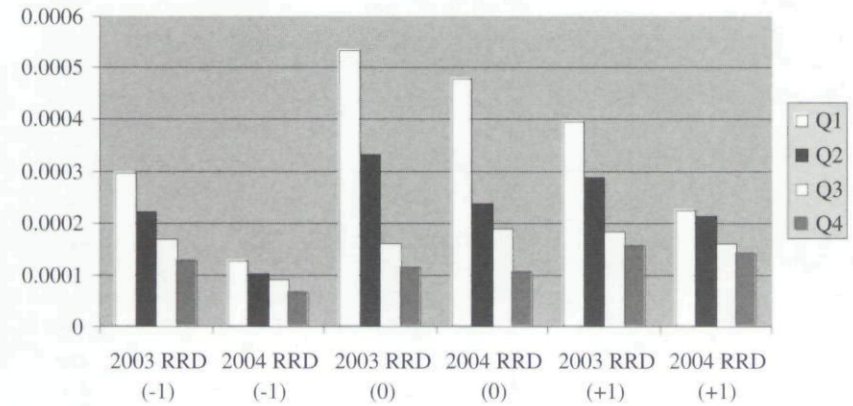


EXHIBIT 6

Median Relative Return Dispersion Estimates for Size-Based Quartiles



CONCLUSION

Closing cross's *raison d'être* lies in the price dislocations that are known to have occurred in the past at Nasdaq closings. Nasdaq is of course not the only market to have faced the problem of achieving reasonable price discovery at the close. In the latter part of the 1990s, the widespread demand of participants for better closing prices led to the introduction of a closing call in Paris and, for the same reason, closing calls have now been instituted throughout all the major market centers in Europe.

Our study of the Paris market in Pagano and Schwartz [2003] suggests that these innovations were successful and because of three call auction features of closing cross, we anticipate a similar result in the Nasdaq market. First, closing cross pools orders for simultaneous execution in a single batched trade at a single price, thereby amassing liquidity and systematically sharpening price determination. Second, as the book builds for the closing auction, order imbalances are displayed to the market. Third, Nasdaq's new facility gives participants time to exploit the imbalances and, in the process, to mitigate them by entering imbalance orders (the IOs).

We have conducted an early assessment of the closing cross by examining the quality of closing price determination in the Nasdaq market on the days at and around the Russell rebalancings in 2003 and 2004. With approximately 1,700 Nasdaq stocks in it and less than three months of experience, the 2004 Russell rebalancing was indeed a tough test of closing cross. Nevertheless, our examination has yielded encouraging results.

Our key test statistic (RRD, a measure of relative return dispersion) indicates a better alignment of prices across the stocks in the Russell 2000 universe at the 2004 rebalancing than at the 2003 event. The improvement was most notable for issues that generally experience the greatest price dislocations, those in the smallest quartile of stocks by market cap.

A caveat is in order, however. Because many factors affect stock returns, it is never easy to isolate the impact of a new market structure on prices. The Russell rebalancing in particular is a complex event, representing different participants with different trading needs and different trading strategies at various times during the day of the rebalancing and on the surrounding days.

Is the improvement in our test statistic attributable to the market structure change? Is it the chance result of participants, for their own reasons, interacting differently at the 2004 rebalancing than at the 2003 rebalancing? Are our findings, in part, attributable to both?

In light of Europe's experience with closing auctions, given our previous analysis of the Paris market and our current findings for the Nasdaq stocks in the Russell rebalancing (especially the improved performance of the smallest-cap stocks that are most subject to pricing dislocations), and based on what one might expect from the architectural design of the facility itself, our conclusion at this time is that the closing cross marks a positive step forward in market structure. We anticipate further benefits to be realized in the future as participants learn how to use Nasdaq's new facility better.

ENDNOTES

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[1]Crossing networks such as ITG's Posit and Instinet's after-hours cross do not provide price discovery. Rather, they match crossing buy and sell orders at a price (either the midpoint of a stock's bid-ask spread or a stock's closing transaction price) that is set in a major market center.

[2]For additional discussion see Economides and Schwartz [1995] and Schwartz and Francioni [2004].

[3]The prearranged trades are the product of bilateral agreements with counterparties who are commonly hedge funds or dealers.

[4]In a letter dated May 16, 2000, to Frank Zarb, then-chairman and chief executive officer of the National Association of Securities Dealers (NASD), Arthur Levitt wrote, "I urge the NASD to pursue a unified opening procedure, and in the interim, to press forward with measures to make the opening process more reliable and fair to investors."

[5]It was reported in *Securities Industry News*, October 13, 2003, that, according to David Blitzer, managing director and chairman of the S&P index committee, "S&P has been unhappy with Nasdaq delays in providing a final closing price, particularly on days with higher-than-normal volumes, cancelled trades that cause delay and uncertainty, and unusual price movement around the close."

[6]Our description is based on information provided on Nasdaq's websites, MKTDATASVC@nasdaq.com and www.NASDAQTrader.com/close, as well as on Sofianos and Su [2004a and 2004b].

[7]IOs that have been priced more aggressively are repriced for the cross at the best 4:00 PM bid or offer.

[8]If two or more prices result in an identical maximum number of shares that will trade, the algorithm for selecting a clearing price includes additional criteria: first, minimize the LOC imbalance and then, if a unique price still cannot be found, minimize the distance from the final midquote value in SuperMontage.

[9]The Nasdaq computer sets the closing price stock-by-stock and reports all the orders that execute for a stock as a single print. Generally, the reports are completed within four seconds of the 4:00 PM cross, and Nasdaq official closing prices (NOCPs) are disseminated at 4:01:30 PM. The process took ten seconds at the Russell rebalancing because of the heavy volume on that day.

[10]The most heavily traded stock in the cross was Cisco (7.45 million shares).

[11]Returns are measured using closing prices. We report changes in the market model's beta parameter in Pagano and Schwartz [2003], but omit them here to conserve space.

[12]The changes in the market model beta between the 1-day and 20-day measurement intervals are also similar to what we observed for the French stocks. To conserve space, we report only results for the 50-stock averages of the 1- and 20-day return intervals rather than for all 12 return intervals.

[13]Before 1990, the rebalancings were more frequent (quarterly during 1979-1986 and semiannually from 1987 to June 30, 1989).

[14]Approximately 275 to 450 stocks are either added to or dropped from the Russell 2000 during a typical rebalancing, so there are 600 to 900 stocks in total affected by this event. Approximately 1,500-1,700 stocks remain within the index from one year to the next.

A Tuesday closing price is used to measure the Tuesday return (Tuesday's closing price relative to Monday's closing price) as well as the Wednesday return (Wednesday's closing price relative to Tuesday's closing price).

[15]Specifically, the beta estimates for the 2003 event are based on data from May 1998 through April 2003, and the 2004 beta estimate is based on data from May 1999 through April 2004. We end each computation period in April so that the estimates would not be biased by potentially confounding effects associated with the Russell 2000 rebalancing activity that begins at the end of May each year.

[16]The –7/+ 7 trading days are chosen to avoid the potentially confounding effects caused by triple-witching expiration dates earlier in June, and the Fourth of July weekend in early July. Days farther yet away from the event dates are not considered because there is a greater chance that, as the event window is lengthened, confounding effects related to changes in marketwide conditions or macroeconomic news might influence the results. The –7/+ 7 trading days represent a reasonable trade-off between these conflicting effects.

[17]Non-parametric Wilcoxon tests and tests based on medians yield essentially the same results reported in Exhibit 3 based on the t-statistic. To conserve space, we report only the t-statistics here. (We also report the median RRD estimates across size-based quartiles in Exhibit 6.)

[18]Along similar lines, one might argue that a substantial difference in the overall market's volatility during the 2003 and 2004 event days could affect our results. For example, if there is less underlying return volatility of the Russell 2000 index in 2004 than in 2003, the 2004 RRDs might be lower than the 2003 RRDs even without introduction of the Nasdaq closing cross. We checked for this possibility by computing the high-low range for the Russell 2000 index (as a percentage of the closing index value) for both event days. The percentage ranges are essentially the same for both years (1.43% and 1.49% for 2003 and 2004, respectively). Thus, a substantial drop in volatility in the Russell 2000 index during the 2004 event did not occur, and our findings are more likely to be attributable to introduction of the closing call.

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