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VOLATILITY, TRADING MECHANISMS AND INTERNATIONAL CROSS-LISTING

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Abstract

Existing market micro-structure literature attributes greater volatility of stock returns at the open of the NYSE, relative to the close, to either the specialist-administered open mechanism or to the extended non-trading period preceding the open. We distinguish between these two hypotheses by examining the return behavior of NYSE stocks that are cross-listed in London and Tokyo. Our results indicate that the open mechanism is *not* a significant determinant of return volatility. Instead, accumulation of orders at the open, relative to the close, is responsible for higher volatility at the open. In fact, after controlling for volume at the open and at the close, we find no evidence that average variances of open-to-open returns are greater than variances of close-to-close returns. We also examine the impact of a security's primary and cross listings on the relative variance of daytime and overnight NYSE returns. Our results generalize earlier findings that return variances of foreign stocks are significantly less than those of U.S. stocks during NYSE trading hours. In addition, we document an interesting asymmetry—Tokyo cross-listings tend to decrease NYSE return variances for U.S. stocks, but London cross-listings have no such effect.

1 Introduction

At the open of trading on the New York Stock Exchange (NYSE), transactions are executed through an auction in which the specialist participates. During the rest of the trading day the market functions as a continuous dealership market. Previous studies [Amihud and Mendelson (1987), and Stoll and Whaley (1990)] have shown that return variances are greater at the open than at the close of trade on the NYSE, and attribute this finding either to the NYSE opening mechanism or to the extended period of non-trading preceding the open. The extent to which either the NYSE open mechanism or the non-trading period affects return variance is important to market designers who must determine the structure of trading mechanisms and the length of the trading period to be used.

Several studies have attempted to determine whether auction mechanisms or the period of non-trading preceding an open is responsible for differences in the variances of open-to-open and close-to-close returns. Amihud and Mendelson (1989) and Amihud, Mendelson and Murgia (1990) compare the behavior of returns across foreign markets whose trading mechanisms differ. Amihud and Mendelson (1991) compares the behavior of returns in morning and afternoon auctions on the Tokyo stock exchange. The morning auction follows an overnight non-trading period, but the afternoon auction is preceded by only two hours of non-trading. They find that larger return variance is associated with the morning auction, and conclude that the higher open return variance is not related to the auction mechanism. However, these auctions are conducted by disinterested auctioneers, which contrasts sharply with the NYSE open mechanism that allows the specialist to participate. As Stoll and Whaley (1990) point out, the NYSE specialist has an incentive to be an active participant at the open, and his participation can significantly alter the behavior of prices at which open transactions are executed.

In this paper, we compare the behavior of open-to-open and close-to-close return variances of NYSE stocks that are traded on foreign exchanges. Since these securities do not have an extended period of non-trading preceding the open of the NYSE, we can isolate the impact of the NYSE open mechanism on the relative variances of open-to-open and close-to-close returns. We find that the non-trading period preceding the open, and not the NYSE open mechanism, is responsible for the larger variance of open-to-open returns documented for NYSE securities. This evidence is consistent with Amihud and Mendelson's study of the Tokyo stock market. Our analysis goes beyond this to examine why the non-trading period is important. We find that the non-trading period leads to substantial order accumulation at the open of the NYSE for U.S. stocks, which in turn, increases return variance. Our estimates suggest that after controlling for volume at the open and at the close, the average ratio of open-to-open and close-to-close return variances is actually less than one. These findings indicate that differences between open and close return variances are not related to the specialist's monopoly power [Stoll and Whaley (1990)] or to the effect that non-trading has on price discovery [Amihud and Mendelson (1991)]. Instead, these variances appear to be a reflection of the volume and price variability relation extensively documented in the literature [see Karpoff (1987) for a survey].

Several studies have examined return variances over trading and non-trading periods [see Oldfield and Rogalski (1980), French and Roll (1986), Barclay, Litzenberger and Warner (1990), Jones, Kaul and Lipson (1991a), and Makhija and Nachtmann (1991)]. The objective of these studies is to assess the impact that trading has on return variances. Our sample enables us to compare securities that can be traded in Tokyo during evening hours when the NYSE is closed, securities that can be traded in London during morning hours when the NYSE is closed, and securities that cannot be traded during these periods. We find that for U.S. stocks, a Tokyo cross-listing is associated with smaller daytime versus overnight return variances, but a London cross-listing appears to have no impact on daytime relative to overnight variances. This suggests that extended evening trading hours on the NYSE might have a greater impact than extended morning trading hours on the variance of security returns realized during NYSE trading hours.

The next section describes the sample and the data we use for our study. Section 3 presents the hypotheses and empirical results concerning variances of open-to-open and close-to-close returns. In these sections we also discuss how our analysis relates to and extends existing literature. Section 4 presents the hypotheses and results for daytime and overnight return variances. Concluding remarks are contained in Section 5.

2 Sample Selection and Data

Our study analyzes the behavior of stock returns during the time period of January 1, 1986 to December 31, 1987. Daily data on prices and volume are obtained from the Institute for the Study of Security Markets (ISSM) transaction file. We construct two groups of internationally cross-listed stocks, the first group is U.S. securities traded abroad and the second group is foreign securities traded on the NYSE. We further sub-divide these groups into seven portfolios of cross-listed stocks. These portfolios consist of: (N^*, L) U.S. stocks listed on the NYSE and London; (N^*, T) U.S. stocks listed on the NYSE and Tokyo; (N^*, L, T) U.S. stocks listed on the NYSE, London and Tokyo; (L^*, N) British stocks listed on the NYSE and London; (L^*, N, T) British stocks listed on the NYSE, London and Tokyo; (T^*, N) Japanese stocks listed on the NYSE and Tokyo; and (T^*, N, L) Japanese stocks listed on the NYSE, Tokyo and London.

The seven portfolios of cross-listed securities include all stocks listed on the NYSE and cross-listed in London and/or Tokyo as of December 1990 that were also listed, or became listed during the sample period. If a stock became dual-listed during this period, it is added to its corresponding portfolio on the first day of the month following the cross-listing date. If a stock became triple-listed (NYSE, London and Tokyo) during the sample period, it is dropped from its dual-listed portfolio and added to its corresponding triple-listed portfolio as of the triple-listing date. For each cross-listed stock, we identify a control stock that is listed on the NYSE as of December 1990, and is not cross-listed on either London or Tokyo between 1986 and 1990. The control stocks are selected as the nearest match by two-digit SIC code (or one-digit SIC code if a match for two-digit SIC is not available), and firm size as measured by the dollar value of equity.

For each stock, we calculate the open-to-open, close-to-close, open-to-close, and close-to-open returns. If transaction prices for a day are not reported on the ISSM file, that day's prices are treated as missing and a return is not computed for that day. We also exclude those days during which there is only one transaction. For each month, we exclude from our tests any security having less than three daily returns during the month.

Table 1 presents descriptive statistics for both cross-listed and control stocks. Included are the monthly average number of stocks in each portfolio, statistics on firm size and daily volume, and the average of stocks' bid-ask spreads. Note from the size and volume statistics that firms in the cross-listed portfolios are much larger and that their stocks trade more actively than the non-cross-listed control stocks. This is a reflection of the fact that large firms whose stocks are actively traded are the ones most likely to be cross-listed.

3 Open and Close Return Variances

Internationally cross-listed stocks can be traded while the NYSE is closed. Therefore, the open of trading on the NYSE is not preceded by an extended period of non-trading for these stocks. This enables us to separate the effect of the NYSE open mechanism from the effect of a preceding non-trading period on the variance of open-to-open returns. We compute the variance of open-to-open returns and the variance of close-to-close returns for each stock in each month. We then form the ratio of open-to-open return variance to close-to-close return variance for each stock in each month. Within the group of U.S. stocks, we compute the cross-sectional median of the ratios for each month; we do the same for the group of foreign stocks. Our hypothesis tests for each portfolio are based on the distribution of these monthly median ratios, which we call open-to-close variance ratios.[1]

For each portfolio, we test the null hypothesis that the mean of the open-to-close variance ratios is equal to one, against the alternative that it is greater than one. If the NYSE open mechanism is a significant determinant of open return variance, then we should reject the null hypothesis for these cross-listed stocks. This is because these stocks trade on the NYSE, so the NYSE open mechanism applies to all of them. Alternatively, if the non-trading period preceding the open is responsible for the larger open return variances documented in earlier studies, we should not reject this null hypothesis. This is because our sample consists of securities that can be traded during the period preceding the NYSE open. Since none of these stocks has an extended non-trading period preceding the open, the effect of such a non-trading period on open return variance is absent from this sample of stocks.[2]

These interpretations require a further refinement. Our sample includes U.S. securities that trade abroad and foreign securities that trade on the NYSE. The behavior of open returns need not be the same for these two groups of securities. If trading is concentrated in a security's home country, then a large proportion of total trading in U.S. securities occurs on the NYSE [see Admati and Pfleiderer (1988), Chowdry and Nanda (1991), Foster and Viswanathan (1990), Freedman (1990) and Subrahmanyam (1990) for models of concentrated trade]. This means that the open-to-open returns for cross-listed U.S. stocks may behave *as if* the open is preceded by a period of non-trading. Consequently, if an extended non-trading period increases the variance of open-to-open returns, and if trading in U.S. securities is concentrated in the U.S., then we should be able to reject the hypothesis that the average

[1]Stoll and Whaley (1990) use this procedure to compute variance ratios, but base their tests on cross-sectional means, recognizing that these means are upward biased due to Jensen's inequality. To avoid this bias, we base our tests on medians; but for comparison, we also present results based on cross-sectional means.

[2]A systematic temporary component of price changes at the open or at the close is necessary to cause open-to-close variance ratios to differ from one. Differences in open-to-open and close-to-close return variances cannot be caused by differences in the flow of information at the open and at the close because these variances involve overlapping 24-hour returns [see Stoll and Whaley (1991) p. 45].

variance ratio is one for the U.S. stocks *only*. The variance ratios of our foreign securities should not be significantly greater than one.

The average open-to-close variance ratios based on cross-sectional medians are presented in Panel A of Table 2 for both cross-listed and control-group stocks. Statistics for the entire sample of cross-listed stocks and the entire sample of control group stocks appear in column 10. For each sample taken as a *whole*, the mean of the variance ratios are both significantly greater than one. This is consistent with the findings of earlier studies [Amihud and Mendelson (1987) and Stoll and Whaley (1990)]. However, these statistics do not account for differences in the stocks' primary listing or cross-listings, and suggest the tentative (but erroneous) conclusion that the NYSE open mechanism is responsible for the large variances of open-to-open returns.

The results are *dramatically* different, however, when we consider foreign and U.S. stocks separately. The mean open-to-close ratio for foreign stocks cross-listed on the NYSE is not significantly different from one (column 9). In fact, the point estimate is less than one, 0.978. This is also significantly less than 1.063, which is the average ratio for the corresponding control group. Moreover, *none of the individual portfolios* of foreign stocks has a mean open-to-close variance ratio significantly greater than one (columns 5 through 8). In fact, the average ratio for Japanese stocks cross-listed on the New York and London exchanges (column 8) is significantly *less* than one. These results support the hypothesis that the non-trading period preceding the NYSE open is responsible for the large open-to-close variance ratios documented in the literature. This is because the cross-listings of these foreign stocks allows them to be traded during the time that the NYSE is closed.

If trading in U.S. stocks is concentrated in the U.S., the open-to-close variance ratios for cross-listed U.S. stocks should be similar to those of the non-cross-listed control group.[3] The

[3]The preference of traders to trade U.S. stocks on the NYSE may be based on transactions costs. Vijh (1990), Ho and Macris (1985), and Forster and George (1992) argue that specialist markets or centralized markets like the NYSE provide cheaper order execution for large liquid stocks than competitive-dealer

evidence is consistent with the hypothesis that trade in U.S. securities is concentrated on the NYSE. The mean open-to-close ratio for U.S. stocks is significantly greater than one and insignificantly different from the non-cross-listed control group (column 4). In fact, *all of the individual portfolios* of U.S. stocks have mean open-to-close variance ratios significantly greater than one (columns 1 through 3).

Panel B of Table 2 contains identical tests based on the distribution of cross-sectional *means.* We include these results for comparison with Stoll and Whaley (1990). However, as Stoll and Whaley point out, these are upward-biased estimates of the average open-to-close variance ratio by Jensen's inequality. This is apparent in the table; the point estimates in Panel B are consistently greater than those in Panel A. This problem is particularly severe for the average ratios of foreign stocks, which are computed using less (cross-sectional) observations than the ratios for the U.S. stocks. However, in spite of this bias, the statistical inferences are identical to those of Panel A.[4]

The evidence presented so far is consistent with the findings of Amihud and Mendelson's (1991) comparison of the morning and afternoon auctions on the Tokyo Stock Exchange. However, the implications of our results are different from theirs in several respects. First, our results include the impact of the specialist's participation at the open of the NYSE. Our finding that the open mechanism appears to be unimportant suggests that the specialist does not behave in a manner that increases the variance of returns at the open. This implies, for example, that the specialist does not use his monopoly power at the open to destabilize prices. Second, our sample includes securities for which a moderate non-trading period precedes the NYSE open (those traded in Tokyo), and securities for which trade is on-going when the NYSE opens (those traded in London). Our results indicate that open-to-close

decentralized markets such as the OTC and London markets. If we had data on foreign transactions costs our sample selection technique would provide a straight-forward empirical test these predictions.

[4]Although there are fewer foreign stocks than U.S. stocks in our sample, the average number of returns per-month used to calculate variance ratios is similar across groups. On average across the U.S. stocks, 18.16 returns per-month are used to calculate open and close return variances; for foreign stocks, the average is 16.25 returns.

variance ratios are not smaller when the non-trading period is shorter. In fact, the average variance ratios reported in Table 2 are smaller for foreign firms that trade only in Tokyo than those that trade in London. This suggests that the length of the non-trading period is not a determinant of the variance of open-to-open returns relative to close-to-close returns. Finally, by separating the sample of cross-listed securities into foreign and domestic, we find evidence consistent with the hypothesis that trade in U.S. stocks is concentrated on the NYSE. It is this evidence that leads us to examine the accumulation of orders at the open, relative to the close, as a potential explanation for the open-to-close variance ratios we observe for these stocks; Amihud and Mendelson's study does not address this issue.

3.1 Open and Close Trading Volume

To investigate why the non-trading period preceding the open might be an important determinant of open return variance, we examine the effect that the non-trading period preceding the open has on the accumulation of orders. We compute the proportion of daily volume executed at the open and the proportion of daily volume executed at the close (first and last transactions of the day, respectively) for each stock each day. For each stock, we compute the average of these proportions across days within each month. Within the group of U.S. stocks, we compute cross-sectional medians of these proportions for each month; we do the same for the group of foreign stocks. Our hypothesis tests for each portfolio are based on the distribution of these monthly medians, which we call open-to-total and close-to-total volume ratios.

Panel A of Table 3 presents averages of the proportion of daily volume executed at the open for cross-listed and control-group stocks. On average, 6.6% of daily volume for cross-listed U.S. stocks is executed at the open; the proportion for the non-cross-listed control stocks is not significantly different (column 4). By contrast, 11.4% of daily volume for foreign stocks is executed at the open, which is significantly greater than the 7.8% for the non-cross-listed control group (column 9).[5] Panel A of Table 4 presents averages of the proportion of daily volume executed during the last transaction of the day for cross-listed and control-group stocks. On average, 2.2% of daily volume for U.S. stocks is executed in the last transaction of the day (column 4); the proportion for the non-cross-listed control stocks is 2.4%. In stark contrast, approximately 9% of daily volume for foreign stocks is executed at the close, which is almost *three times* as large as the point estimate of 3.6% for the non-cross-listed control group (column 9). This evidence suggests that a significant proportion of the demand for order execution for foreign stocks occurs at the open, and an even larger proportion occurs at the close, *relative to non-cross-listed U.S. stocks.*

The variance ratios we wish to explain are comparisons between the open and close variances of individual stocks. Consequently, the appropriate comparison of volume statistics is between open and close volume for foreign stocks, and open and close volume for U.S. Stocks. For each portfolio, we test the hypothesis that the open-to-total and close-to-total volume ratios are equal. If the accumulation of orders at the open is a significant determinant of open return variance, we should be able to reject this hypothesis for our sample of cross-listed stocks. In addition, if trade is concentrated, we should be able to reject this hypothesis for the cross-listed U.S. stocks. However, the open-to-total and close-to-total volume ratios of the foreign stocks should not be significantly different.

Table 5 presents the results of a test of the hypothesis that the proportion of volume executed at the open is equal to the proportion executed at the close for each portfolio of cross-listed stocks. For U.S. stocks, open volume is 6.6% of daily volume, more than triple the 2.1% executed at the close; these differences are statistically significant (column 4). Furthermore, these differences are statistically significant for *each of the individual portfolios* of cross-listed U.S. stocks (columns 1 through 3). Alternatively, for foreign stocks, open

[5] Panel B presents similar comparisons based on cross-sectional means. The results are similar to those in Panel A.

volume is 11.4%, and close volume is 9%, of daily volume (column 9). While this difference is statistically significant, the proportion of volume executed at the open is only 1.25 times as large as the proportion executed at the close.[6] This evidence suggests that the non-trading period that precedes the open is associated with a significant accumulation of orders at the open (relative to the close) for cross-listed and non-cross-listed U.S. stocks, but not for foreign stocks.

3.2 Regression Results

The tests described so far focus on the similarity of average variance ratios and average differences between open and close volume. To assess the strength of the cross-sectional relation between these variables, we regress the open-to-close variance ratios on volume at the open relative to the close. Significance of the coefficients on volume indicates whether the accumulation of orders at the open, relative to the close, is a significant determinant of cross-sectional variation in open-to-close variance ratios. If order accumulation is responsible for large open-to-close variance ratios, the coefficient on open volume should be positive, and the coefficient on close volume should be negative.

This regression approach has two added benefits. First, we are able to examine the extent to which differences in variance ratios between U.S. and foreign cross-listed stocks are explained by differences in open and close volume. If significant differences disappear after controling for open and close volume, then the non-trading period preceding the open has no effect on return variances beyond differences in the accumulation of orders at the open and at the close. Second, we can use the coefficient estimates to determine the expected variance ratio if open and close volume were equal. Finding that the expected variance ratio exceeds one is consistent with the hypothesis that the open mechanism is an important determinant

[6]Panel B contains tests based on cross-sectional means. The results is similar to those in Panel A.

of open return variance. The opposite finding suggests that large open return variances are due entirely to differences in order accumulation at the open and the close.

Table 6 presents results from two cross-sectional regressions. The dependent variable in these regressions is the natural logarithm of open-to-close variance ratios; the independent variables are the natural logarithm of the monthly average of daily open volume, the natural logarithm of the monthly average of daily close volume, a dummy intercept, and interactive terms for the dummy and the volume variables. The dummy indicates whether the observation corresponds to a U.S. security.[7] The interactive terms indicate whether the relation between variance ratios and volume is different for U.S. and foreign securities. The dummy intercept captures the incremental explanatory power of whether the security is domestic or foreign, controlling for differences in volume. This variable is important for testing whether securities' home countries have explanatory power for variance ratios that is incremental to that of open and close volume. If not, the dummy intercept should be insignificant.

For our sample of cross-listed stocks, we find that the ratio of open and close return variances is positively related to the volume of orders executed at the open, and negatively related to the volume of orders executed at the close. The coefficient estimates on the logarithm of open and close volume are 0.09 and -0.12, respectively. Furthermore, the coefficients on the interactive terms are insignificantly different from zero implying that whether a security is foreign or domestic does not alter the relation between variance ratios and our measures of volume. The evidence also indicates that greater volume at the open and smaller volume at the close fully accounts for the large average variance ratios observed for U.S. securities, compared to foreign securities. After controlling for open and close volume, the dummy variable that distinguishes between the average variance ratios of U.S. and foreign stocks is

[7]We choose the logarithmic specification in favor of a regression of the variance ratio on the ratio of open and close volumes because the logarithmic specification places less restrictions on the relation we wish to estimate. This is because separate regression coefficients are estimated for open and close volume using the logarithmic specification. Therefore, the incremental effects of open and close volume are not restricted to be equal as they are with the ratio specification.

insignificant. These findings are consistent with the hypothesis that relative differences in the extent of order accumulation at the open and at the close are important determinants of the large variance of open returns relative to close returns.

Like the earlier tables, the regression results suggest that large open-to-close variance ratios are not related to the NYSE open mechanism, but instead are related to large volume at the open *relative* to the close of trading. If the NYSE open mechanism were responsible for large open-to-close variance ratios, then the *average* ratio should exceed one even if volume were equal at the open and at the close. The intercept and volume coefficient estimates in Table 6 imply that if open and close volume are equal, the *expected* natural logarithm of open-to-close variance is zero or negative. Although not a sufficient condition, this is consistent with an average ratio that is less than or equal to one.[8]

The regression results also provide evidence that is inconsistent with the hypothesis that call auctions at the open of trading are responsible for greater volatility at the open. Only the most actively traded stocks on the NYSE consistently open with a call auction. Consequently, the longer is the delay before the start of trading, the less likely is trading to open with an auction. To examine whether large variance ratios are associated with auctions at the open, we reestimate the cross-sectional regression of open-to-close volume ratios after including the average open delay as an explanatory variable. The second panel of Table 6 presents the results from this regression. The two important aspects of these results are that the open delay variable is insignificant, and the significance of the other variables is unaffected by including open delay as an explanatory variable. In this regression, natural logarithms of open and close volume continue to be the only significant explanatory variables and the numerical values of the coefficient estimates are identical to the values they take

[8]This evidence is consistent with a theoretical result obtained by Madhavan (1992) who compares the behavior of prices in continuous markets where orders are executed one at a time, and periodic markets where orders are batched. He shows that price volatility is lower when orders are batched than when executed one at a time. This is because idiosyncratic motivations for trading exert a larger influence on prices when trades are executed one at a time, but are diversified away when orders are batched.

in the regression without open delay included. These results are further evidence that the mechanism used at the open is not an important determinant of return volatility, but that differences in relative volatilities at the open and close are due to differences in trading volume.

The regressions reported in Table 6 also include a dummy variable for October of 1987. This variable is significantly negative, implying that the variance of close returns is significantly greater than the variance of open returns during the period surrounding the crash.

4 Day and Night Return Variances

Our second set of tests focuses on the effect that the length of the trading period has on the variance of returns realized while the NYSE is open relative to the variance of returns realized while the NYSE is closed. This enables us to test whether the variance of returns realized while the NYSE is open depends on whether a foreign stock has Tokyo or London as its primary listing. Similarly, we can assess the impact that a foreign cross-listing has on the variance of daytime returns for U.S. stocks, and whether this impact depends on the country in which the stock is cross-listed. For these tests, we compute the ratio of daytime return variance to overnight return variance for each stock in each month. Within each group (and each portfolio), we compute the cross-sectional medians of the ratios for each month. Our hypothesis tests are based on the distribution of these monthly medians, which we call day-to-night variance ratios. We compute identical statistics for the non-cross-listed NYSE control stocks that match those in each group (and portfolio).

For each portfolio, we test whether the median day-to-night ratio for the cross-listed stocks is equal to the median day-to-night ratio for the control group stocks. If the variance of returns realized while the NYSE is open, relative to when the NYSE is closed, is affected by a security's primary listing or cross-listing(s), the ratios for cross-listed and control-group stocks will not be equal. In addition, if the effects of cross-listing in different countries are not the same, the magnitude of the differences between median ratios will vary accordingly.

Panel A of Table 7 presents ratios of daytime and overnight return variances for each of the seven portfolios and their non-cross-listed control groups. Ratios for the entire cross-listed sample are insignificantly different from the ratios for control-group stocks (column 10). However, when the cross-listed sample is separated based on primary listing and cross-listing countries, there are considerable differences in these ratios across the portfolios. For five of the seven portfolios, the average day-to-night variance ratios for cross-listed stocks are significantly less than the ratios for their non-cross-listed control stocks.

Our results generalize the findings of Barclay, Litzenberger and Warner (1990) who compare U.S. stocks listed in Tokyo and Japanese stocks listed on the NYSE with control groups of non-cross-listed stocks. Columns 2 and 3, and 7 and 8, of Table 6 represent their partitions of the data. Columns 2 and 3 are U.S. stocks listed in Tokyo and columns 7 and 8 are Japanese stocks listed on the NYSE. Consistent with Barclay, Litzenberger and Warner, we find that day-to-night variance ratios of U.S. stocks listed in Tokyo are similar in magnitude to the control-group ratios, but that the ratios for Japanese stocks are significantly less than the control-group ratios. Our results confirm their conclusion for Japanese stocks and extend it to the comparison between cross-listed U.S. stocks and a broader set of foreign stocks—Japanese *and* British. The average day-to-night variance ratios of cross-listed and non-cross-listed U.S. stocks are not significantly different, whereas the average day-to-night ratio of foreign stocks is one-tenth the ratio of the non-cross-listed control group. This is consistent with the joint hypothesis that variances reflect the flow of information into prices [see French and Roll (1986) and Ross (1989)], and that more information is produced while the stock's market of primary listing is open. This is also consistent with the hypothesis that trade is concentrated in a security's home country.[9]

[9]Panel B contains the same analysis using cross-sectional means. The results are qualitatively the same

To examine differences between these ratios, we regress the natural logarithm of the day-to-night variance ratios of cross-listed and control stocks on dummy variables that indicate the portfolio to which each cross-listed stock belongs. Significance of the regression coefficients for these variables indicates the significance of the effect of a particular combination of primary and cross listing on the return variance realized while the NYSE is open. Differences in the regression coefficients among the portfolios of U.S. securities indicate the effect of additional cross-listings on U.S. securities. For example, the difference between the coefficients corresponding to dummy variables for portfolios of U.S. stocks listed in London and U.S. stocks listed in London and Tokyo is a measure of the incremental effect of a Tokyo cross-listing on the day-to-night variance ratio of a U.S. stock listed in London.

The regression results presented in Table 8 display a striking asymmetry. We find that a London cross-listing has no effect on the day-to-night variance ratios of U.S. stocks; however, a significant decrease in the day-to-night variance ratio is associated with a Tokyo cross-listing. Assuming that return variance is a result of the flow of information into prices, this evidence suggests that a Tokyo cross-listing significantly increases the rate of information flow into prices when the NYSE is closed; but a London cross-listing has no such effect. One reason for this might be that the Tokyo market is open during hours when public and private information are more likely to be produced. By contrast, the London market opens at 4:30am Eastern Standard Time. These findings also suggest that extending NYSE trading hours in the morning would have no effect on the relative variance of returns realized on the NYSE, but extending the afternoon trading hours would significantly decrease this variance.[10]

as those in Panel A.

[10]There is one caveat to interpreting our results as indicative of information flow. Jones, Kaul and Lipson (1991a) note that transaction-returns based variance estimates are upward biased estimates of *true* return variances because of bid-ask-bounce. Consequently, variance ratios computed from transaction returns will be biased toward one, relative to day-to-night variance ratios computed from true returns. However, in their study of weekend-to-weekday returns for NASDAQ stocks, the bias appears to be small for large firms. Since bid-ask bounce is likely to be a smaller proportion of return variance for the stocks in our sample, the bias in day-to-night variance ratios is also likely to be small. While their caveat applies to our results on day-to-night variance ratios, it has no relevance for our results in connection with open-to-close variance ratios and volumes because our objective was to analyze *transaction* return variances—including effects associated

We also find that a London (Tokyo) cross-listing does not affect the day-to-night variance ratios of Japanese (British) stocks that trade on the NYSE. This suggests that additional cross-listings of foreign securities does not affect the variance of returns realized while the NYSE is open relative to when the NYSE is closed. To account for differences related to the crash, we include a dummy variable for October, 1987. This variable is significantly negative, which indicates that the crash-related volatility was actually greater during the hours when the NYSE was closed than when it was open.

5 Conclusion

In this paper, we study the relative open and close return variances of NYSE stocks. Our sample selection technique enables us to determine whether the NYSE open mechanism itself, or the non-trading period preceding the open, is responsible for the relatively greater variance of returns at the open. The evidence is consistent with the hypothesis that the mechanism is not an important determinant of relative open-to-open and close-to-close return volatility. Instead, our results indicate that the non-trading period preceding the open is associated with an accumulation of orders at the open, which in turn is responsible for greater volatility at the open.

Our results suggest that large relative open variances could simply be a manifestation of the volume and price variability relation previously documented in the literature [see Karpoff (1987) for a survey, and Jones, Kaul and Lipson (1991b) for recent evidence]. A cross-sectional regression analysis involving open-to-close variance ratios, and volume at the open and at the close, supports this hypothesis. The relation between variance ratios and volume is the same for both U.S. and foreign stocks and, after controlling for differences in open and close volume, the average (logarithmic) open and close return variances are not significantly different from each other. This evidence is inconsistent with the hypothesis

with bid-ask spreads that might imply different variances for open and close returns.

that specialists exploit their monopoly power in a manner that destabilizes prices at the open relative to the close.

We also investigate how the length of a security's trading period, which is determined by its cross-listings, affects comparisons of daytime and overnight return variances. Consistent with Barclay, Litzenberger and Warner (1990), we find that while the average day-to-night variance ratio of cross-listed U.S. stocks is not significantly different from that of a matched sample of non-cross-listed stocks, the average day-to-night variance ratio of cross-listed foreign stocks is approximately one-tenth the average ratio for a matched sample of non-cross-listed U.S. stocks. Surprisingly, however, we find that day-to-night variance ratios of U.S. stocks are unaffected by a London cross-listing, but are significantly decreased by a Tokyo cross-listing. If return variances reflect the assimilation of information into prices [see French and Roll (1986) and Ross (1989)], these findings suggest that (i) information flows into security prices at a faster rate when the stock's market of primary listing is open, and (ii) an extension of NYSE afternoon trading hours may enhance the flow of information into the prices of U.S. stocks, but an extension of morning trading hours would have little or no effect.

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Table 1: Descriptive Statistics

	Portfolio						
Cross-Listed Firms	(N^*, L)	(N^*, T)	(N^*, L, T)	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)
Average Number of Firms	116.16	6.17	20.42	7.25	1.75	2.375	5.2083
Mean Firm Size	3922.891	6447.134	13719.579	6704.852	7506.925	5603.595	4576.317
Median Firm Size	3830.058	6070.316	13353.163	7089.312	5287.463	5693.951	4696.579
Mean NYSE Daily Volume	2753.801	4495.495	5972.837	1513.281	1951.937	427.032	606.864
Mean NYSE Open Volume	162.310	337.109	400.263	95.838	121.614	28.145	36.841
Mean NYSE Close Volume	57.227	108.715	138.379	40.565	32.535	21.243	24.323
Mean Quoted Bid-Ask Spread	2.960	0.486	0.544	0.774	1.074	0.441	0.649
Control Firms							
Mean Firm Size	1749.334	3012.802	3504.165	3458.108	4138.590	1645.330	2566.100
Median Firm Size	1730.884	2782.392	3571.584	3878.609	1613.895	1386.945	2625.567
Mean NYSE Daily Volume	1685.823	2258.588	2267.026	2756.197	1879.914	878.448	1251.799
Mean NYSE Open Volume	93.532	119.796	130.416	190.636	167.616	55.791	80.351
Mean NYSE Close Volume	34.347	38.549	42.785	42.896	47.114	16.948	27.766
Mean Quoted Bid-Ask Spread	1.154	0.713	0.798	0.666	4.144	1.118	0.594

Listing variables of N, L and T stand for NYSE, London and Tokyo respectively. Asterisks signify the market of primary listing. Firm Size is the value of equity outstanding in thousands of dollars. Volume is the number of shares traded daily in hundreds. Bid-Ask Spread is stated as a percent of the midpoint of the inside quotes prior to the last transaction of the day.

Table 2: Open-to-Close Variance Ratios

	Portfolio									
Panel A - Medians	(N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks	Foreign & U.S. Stocks
Mean Open Variance	0.459	0.533	0.419	0.454	0.430	0.510	0.772	0.558	0.470	0.454
for Cross-Listed Stocks (x1000)	(0.126)	(0.167)	(0.111)	(0.126)	(0.126)	(0.127)	(0.191)	(0.127)	(0.125)	(0.126)
Mean Close Variance	0.497	0.489	0.494	0.498	0.440	0.955	0.822	0.677	0.556	0.498
for Cross-Listed Stocks (x1000)	(0.187)	(0.173)	(0.213)	(0.194)	(0.152)	(0.560)	(0.245)	(0.188)	(0.178)	(0.192)
Mean Open Variance	0.483	0.602	0.423	0.483	0.520	0.550	0.536	0.541	0.502	0.486
for Control Group (x1000)	(0.110)	(0.193)	(0.122)	(0.121)	(0.141)	(0.205)	(0.161)	(0.227)	(0.151)	(0.126)
Mean Close Variance	0.494	0.532	0.446	0.493	0.553	0.676	0.591	0.541	0.551	0.496
for Control Group (x1000)	(0.157)	(0.175)	(0.172)	(0.162)	(0.223)	(0.343)	(0.266)	(0.261)	(0.241)	(0.168)
Mean Ratio for	1.075	1.156	1.077	1.075	1.055	1.033	1.009	0.898	0.978	1.066
Cross-Listed Stocks	(0.024)	(0.070)	(0.042)	(0.026)	(0.038)	(0.110)	(0.054)	(0.036)	(0.023)	(0.025)
Wilcoxon Statistic	3.554	1.908	2.457	3.554	1.360	1.000	0.811	-3.005	-0.811	3.554
Mean Ratio for	1.061	1.151	1.083	1.072	1.137	1.039	1.225	1.027	1.063	1.070
Control Group	(0.021)	(0.062)	(0.028)	(0.022)	(0.041)	(0.088)	(0.117)	(0.032)	(0.027)	(0.022)
Mann-Whitney Statistic	0.461	-0.176	-0.198	0.044	-1.604	0.255	-1.516	-2.504	-2.351	-0.242

Panel A: Return variances are computed for each firm each month. The cross-sectional median is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly medians. Variance ratios are computed for each firm each month, then cross-sectional medians are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly median ratios. The Wilcoxon Statistics are distributed approximately standard normal under the hypothesis that the central location of the distribution of monthly average ratios is one. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistics reported in row 7 are distributed approximately standard normal under the hypothesis that the distributions of the monthly median ratios are identical for cross-listed and control-group stocks.

Table 2 (cont.): Open-to-Close Variance Ratios

	Portfolio									
Panel B - Averages	(N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks	Foreign & U.S. Stocks
Mean Open Variance for Cross-Listed Stocks (x1000)	0.709 (0.242)	0.574 (0.189)	1.100 (0.508)	0.784 (0.247)	0.621 (0.187)	1.436 (0.826)	0.809 (0.018)	0.687 (0.147)	0.728 (0.148)	0.779 (0.233)
Mean Close Variance for Cross-Listed Stocks (x1000)	0.717 (0.281)	0.732 (0.268)	1.142 (0.521)	0.805 (0.288)	0.612 (0.202)	7.008 (5.738)	0.866 (0.244)	0.717 (0.181)	1.199 (0.192)	0.847 (0.319)
Mean Open Variance for Control Group (x1000)	1.055 (0.328)	0.766 (0.232)	0.556 (0.165)	0.952 (0.278)	0.560 (0.129)	0.975 (0.095)	0.570 (0.159)	0.513 (0.181)	0.594 (0.192)	0.911 (0.264)
Mean Close Variance for Control Group (x1000)	0.835 (0.274)	0.740 (0.260)	0.557 (0.199)	0.790 (0.259)	0.561 (0.185)	1.202 (0.852)	0.627 (0.265)	0.548 (0.225)	0.628 (0.265)	0.771 (0.259)
Mean Ratio for Cross-Listed Stocks	1.249 (0.103)	1.207 (0.072)	1.150 (0.045)	1.229 (0.085)	1.358 (0.250)	1.014 (0.105)	1.032 (0.054)	1.237 (0.332)	1.242 (0.159)	1.230 (0.078)
Wilcoxon Statistic	4.651	3.005	3.005	5.200	3.005	-0.940	1.360	-2.460	1.360	4.651
Mean Ratio for Control Group	1.385 (0.180)	1.330 (0.149)	1.137 (0.028)	1.353 (0.156)	1.188 (0.041)	1.047 (0.077)	1.290 (0.121)	1.129 (0.043)	1.181 (0.033)	1.331 (0.137)
Mann-Whitney Statistic	-0.571	-0.242	-0.022	-0.571	-1.120	-0.302	-1.823	-2.900	-3.493	-0.549

Panel B: Return variances are computed for each firm each month. The cross-sectional average is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly averages. Variance ratios are computed for each firm each month, then cross-sectional averages are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly average ratios. The Wilcoxon Statistics are distributed approximately standard normal under the hypothesis that the central location of the distribution of monthly average ratios is one. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistics reported in row 7 are distributed approximately standard normal under the hypothesis that the distributions of the monthly average ratios are identical for cross-listed and control-group stocks.

Table 3: Open-to-Total Daily Volume Ratios

Panel A - Medians	Portfolio								
	(N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks
Mean Open Volume for Portfolio	101.412 (7.989)	322.738 (21.981)	363.783 (26.804)	262.644 (18.214)	50.388 (5.965)	93.498 (25.641)	26.536 (3.068)	29.141 (3.869)	43.969 (4.962)
Mean Total Volume for Portfolio	1881.682 (88.747)	4255.778 (274.080)	5246.563 (256.678)	3794.674 (213.002)	1164.664 (161.982)	1504.562 (473.241)	402.951 (64.948)	421.617 (69.939)	787.742 (98.890)
Mean Open Volume for Control	52.203 (3.665)	108.035 (7.677)	65.636 (8.144)	75.291 (4.825)	110.069 (10.596)	206.847 (67.782)	56.986 (4.241)	58.090 (5.961)	99.857 (14.273)
Mean Total Volume for Control	1026.996 (43.405)	2042.992 (87.646)	1285.052 (118.095)	1451.680 (72.593)	1861.564 (169.509)	2173.786 (645.880)	913.176 (58.976)	1102.575 (75.009)	1458.339 (140.492)
Mean Ratio for Portfolio (x100)	6.007 (0.176)	7.302 (0.222)	6.479 (0.224)	6.596 (0.135)	7.778 (0.460)	21.348 (3.794)	9.651 (0.791)	11.643 (0.812)	11.419 (0.807)
Mean Ratio for Control Group (x100)	6.181 (0.169)	5.698 (0.282)	5.769 (0.165)	5.883 (0.124)	6.282 (0.183)	9.157 (0.641)	10.509 (0.867)	5.743 (0.295)	7.821 (0.353)
Mann-Whitney Statistic	-0.945	3.537	2.263	3.360	2.285	2.298	-0.615	4.899	4.213

Panel A: Average open and total daily volume are computed for each firm each month. The cross-sectional median is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly medians. Volume ratios are computed for each firm each month, then cross-sectional medians are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly median ratios. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistic reported in row 7 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly median ratios are identical for cross-listed and control-group stocks.

Table 3 (cont.): Open-to-Total Daily Volume Ratios

Panel B - Averages	Portfolio								
	(N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks
Mean Open Volume for Portfolio	162.311 (13.291)	337.109 (24.697)	400.263 (31.513)	299.894 (18.463)	95.838 (12.574)	121.614 (35.341)	28.145 (3.251)	36.841 (3.805)	63.683 (7.528)
Mean Total Volume for Portfolio	2753.801 (120.416)	4495.495 (240.201)	5972.837 (246.085)	4407.378 (199.427)	1513.281 (159.899)	1951.937 (589.618)	427.032 (64.232)	606.864 (78.153)	1012.448 (119.174)
Mean Open Volume for Control	93.532 (7.061)	119.796 (9.593)	130.416 (13.776)	114.581 (6.269)	190.636 (13.845)	167.616 (50.778)	55.791 (4.378)	80.351 (14.026)	119.974 (12.452)
Mean Total Volume for Control	1685.823 (71.703)	2258.588 (96.543)	2267.026 (168.600)	2070.479 (75.586)	2756.197 (134.601)	1879.914 (534.588)	878.448 (57.554)	1251.799 (102.713)	1676.080 (135.473)
Mean Ratio for Portfolio (x100)	6.723 (0.168)	7.446 (0.223)	6.505 (0.198)	6.891 (0.122)	10.275 (0.534)	23.185 (3.326)	10.689 (1.064)	14.813 (0.543)	13.594 (0.777)
Mean Ratio for Control Group (x100)	7.360 (0.145)	5.788 (0.258)	6.245 (0.131)	6.464 (0.133)	6.486 (0.196)	9.218 (0.639)	10.977 (0.746)	5.937 (0.267)	8.067 (0.338)
Mann-Whitney Statistic	-2.834	3.867	0.505	1.614	5.251	3.644	-0.681	5.800	6.674

Panel B: Average open and total daily volume are computed for each firm each month. The cross-sectional average is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly averages. Volume ratios are computed for each firm each month, then cross-sectional averages are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly average ratios. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistic reported in row 7 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly average ratios are identical for cross-listed and control-group stocks.

Table 4: Close-to-Total Daily Volume Ratios

Panel A - Medians	Portfolio								
	(N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks
Mean Close Volume for Portfolio	34.093 (2.563)	97.270 (9.518)	97.464 (13.203)	76.275 (6.509)	30.546 (2.506)	29.040 (8.418)	20.325 (2.133)	19.759 (2.057)	24.358 (1.711)
Mean Total Volume for Portfolio	1881.682 (88.747)	4255.778 (274.080)	5246.563 (256.677)	3794.674 (213.002)	1164.664 (161.982)	1504.562 (473.241)	402.951 (64.948)	421.617 (69.939)	787.742 (98.890)
Mean Close Volume for Control	21.714 (1.030)	33.606 (3.468)	27.293 (2.417)	27.538 (1.545)	28.274 (1.862)	51.424 (14.184)	16.685 (1.591)	24.209 (1.410)	28.396 (3.003)
Mean Total Volume for Control	1026.996 (43.405)	2042.992 (87.646)	1285.052 (118.095)	1451.680 (72.593)	1861.564 (169.509)	2173.786 (645.880)	913.176 (58.979)	1102.575 (75.009)	1458.339 (140.497)
Mean Ratio for Portfolio (x100)	2.207 (0.121)	2.222 (0.172)	2.066 (0.147)	2.165 (0.085)	5.399 (0.462)	17.913 (4.631)	8.153 (0.768)	8.923 (0.795)	9.036 (0.863)
Mean Ratio for Control Group (x100)	2.674 (0.113)	1.953 (0.149)	2.608 (0.164)	2.412 (0.091)	2.023 (0.131)	4.014 (0.533)	5.771 (0.644)	2.604 (0.136)	3.569 (0.261)
Mann-Whitney Statistic	-3.186	1.472	-2.263	-2.206	5.536	1.648	2.175	5.624	7.392

Panel A: Average close and total daily volume are computed for each firm each month. The cross-sectional median is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly medians. Volume ratios are computed for each firm each month, then cross-sectional medians are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly median ratios. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistic reported in row 7 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly median ratios are identical for cross-listed and control-group stocks.

Table 4 (cont.): Close-to-Total Daily Volume Ratios

Panel B - Averages	Portfolio								
	(N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks
Mean Close Volume for Portfolio	57.227 (5.038)	108.715 (9.669)	138.379 (16.317)	101.440 (7.620)	40.565 (3.758)	32.535 (8.615)	21.243 (2.247)	24.323 (2.068)	29.277 (2.032)
Mean Total Volume for Portfolio	2753.801 (120.416)	4495.495 (240.201)	5972.837 (246.085)	4407.378 (199.427)	1513.281 (159.900)	1951.937 (589.618)	427.032 (64.232)	606.864 (78.153)	1012.448 (119.174)
Mean Close Volume for Control	34.347 (1.950)	38.549 (3.546)	42.785 (4.859)	38.560 (2.118)	42.896 (3.913)	47.114 (13.121)	16.948 (1.582)	27.766 (1.493)	32.574 (2.981)
Mean Total Volume for Control	1685.823 (71.703)	2258.588 (96.543)	2267.026 (168.600)	2070.479 (75.586)	2756.197 (134.601)	1879.914 (534.588)	878.448 (57.554)	1251.799 (102.713)	1676.080 (135.473)
Mean Ratio for Portfolio (x100)	3.101 (0.119)	2.414 (0.197)	2.247 (0.179)	2.587 (0.106)	8.861 (0.659)	20.428 (3.952)	9.192 (0.980)	13.610 (0.629)	12.017 (0.813)
Mean Ratio for Control Group (x100)	4.242 (0.118)	2.140 (0.162)	3.564 (0.178)	3.315 (0.138)	2.593 (0.152)	4.170 (0.496)	6.291 (0.536)	2.961 (0.171)	3.990 (0.243)
Mann-Whitney Statistic	-4.921	1.296	-4.636	-3.871	5.800	4.062	2.043	5.800	9.472

Panel B: Average close and total daily volume are computed for each firm each month. The cross-sectional average is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly averages. Volume ratios are computed for each firm each month, then cross-sectional averages are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly average ratios. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistic reported in row 7 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly average ratios are identical for cross-listed and control-group stocks.

Table 5: Comparison of Open and Close Volume Ratios

Panel A - Medians	Portfolio (N^*,L)	(N^*,T)	(N^*,L,T)	U.S. Stocks	(L^*,N)	(L^*,N,T)	(T^*,N)	(T^*,N,L)	Foreign Stocks
Mean Open Ratio for Portfolio (x100)	6.007 (0.176)	7.302 (0.222)	6.479 (0.224)	6.596 (0.135)	7.778 (0.460)	21.348 (3.794)	9.651 (0.791)	11.643 (0.812)	11.419 (0.807)
Mean Close Ratio for Portfolio (x100)	2.207 (0.121)	2.222 (0.172)	2.066 (0.147)	2.165 (0.847)	5.399 (0.462)	17.913 (4.631)	8.153 (0.768)	8.923 (0.795)	9.036 (0.863)
Mann-Whitney Statistic	5.800	5.800	5.800	10.135	3.383	0.895	1.142	2.241	3.621

Panel A: Mean open and close ratios, and their standard errors, are reproduced from Panel A of Tables 3 and 4. The Mann-Whitney Statistic reported in row 3 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly median open and close ratios are identical.

Panel B - Averages	Portfolio (N^*,L)	(N^*,T)	(N^*,L,T)	U.S. Stocks	(L^*,N)	(L^*,N,T)	(T^*,N)	(T^*,N,L)	Foreign Stocks
Mean Open Ratio for Portfolio (x100)	6.723 (0.168)	7.446 (0.223)	6.505 (0.198)	6.891 (0.122)	10.275 (0.534)	23.185 (3.326)	10.689 (1.064)	14.813 (0.543)	13.594 (0.777)
Mean Close Ratio for Portfolio (x100)	3.101 (0.119)	2.414 (0.197)	2.247 (0.179)	2.587 (0.106)	8.861 (0.659)	20.428 (3.952)	9.192 (0.980)	13.610 (0.629)	12.017 (0.813)
Mann-Whitney Statistic	5.800	5.778	5.756	10.092	1.758	0.837	1.011	1.582	2.060

Panel B: Mean open and close ratios, and their standard errors, are reproduced from Panel B of Tables 3 and 4. The Mann-Whitney Statistic reported in row 3 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly average open and close ratios are identical.

TABLE 6: Cross-Sectional Regressions
Open-To-Close Variance Ratios

$$R_{it}^{oc} = \alpha_o + \alpha_1\ US_i + \beta_1\ \ln(VolO_{it}) + \beta_2\ \ln(VolC_{it}) + \delta_1\ US_i \ln(VolO_{it}) + \delta_2\ US_i \ln(VolC_{it}) + \gamma\ OCT_t + \epsilon_{it}$$

α_o	α_1	β_1	β_2	δ_1	δ_2	γ	Adj. R^2
0.060 (0.396)	-0.006 (-0.041)	0.088 (3.022)	-0.123 (-1.930)	-0.041 (-1.374)	0.071 (1.111)	-0.452 (-9.240)	0.059

$$R_{it}^{oc} = \alpha_o + \alpha_1\ US_i + \beta_1\ \ln(VolO_{it}) + \beta_2\ \ln(VolC_{it}) + \delta_1\ US_i \ln(VolO_{it}) + \delta_2\ US_i \ln(VolC_{it}) + \gamma\ OCT_t + \kappa\ Delay_{it} + \epsilon_{it}$$

α_o	α_1	β_1	β_2	δ_1	δ_2	γ	κ	Adj. R^2
0.081 (0.558)	-0.023 (-1.521)	0.085 (2.696)	-0.125 (-1.978)	-0.039 (-1.234)	0.073 (1.158)	-0.450 (-9.071)	-5.272×10^{-6} (-0.346)	0.059

R_{it}^{oc} is the open-to-close variance ratio for internationally cross-listed stock i in month t. US_i equals one if stock i has the NYSE as its primary listing, and equals zero otherwise. $VolO_{it}$ and $VolC_{it}$ are the averages of open and close volume for stock i in month t. OCT_t equals one if month t is October 1987, and equals zero otherwise. $Delay_{it}$ is the average open delay in seconds for stock i in month t. Ordinary least squares estimates are reported in the table. The t-statistics that appear in parentheses are adjusted for heteroskedasticity using White's heteroskedasticity-consistent estimate of the covariance matrix of the coefficient estimates. 3,604 observations.

Table 7: Day-to-Night Variance Ratios

Panel A - Medians	Portfolio (N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks	Foreign & U.S. Stocks
Mean Overnight Variance for Cross-Listed Stocks (x1000)	0.108 (0.054)	0.207 (0.129)	0.145 (0.087)	0.121 (0.066)	0.267 (0.118)	0.702 (0.468)	0.686 (0.187)	0.478 (0.129)	0.331 (0.117)	0.132 (0.072)
Mean Daytime Variance for Cross-Listed Stocks (x1000)	0.372 (0.108)	0.365 (0.101)	0.347 (0.116)	0.365 (0.108)	0.155 (0.036)	0.315 (0.210)	0.154 (0.052)	0.130 (0.038)	0.141 (0.041)	0.338 (0.098)
Mean Overnight Variance for Control Group (x1000)	0.104 (0.045)	0.147 (0.076)	0.085 (0.041)	0.103 (0.047)	0.115 (0.061)	0.290 (0.198)	0.152 (0.068)	0.076 (0.040)	0.114 (0.059)	0.105 (0.049)
Mean Daytime Variance for Control Group (x1000)	0.381 (0.091)	0.417 (0.100)	0.307 (0.073)	0.376 (0.091)	0.384 (0.110)	0.492 (0.224)	0.453 (0.116)	0.418 (0.156)	0.388 (0.121)	0.376 (0.094)
Mean Ratio for Cross Listed Stocks	5.304 (0.360)	4.624 (0.589)	4.902 (0.391)	5.203 (0.364)	1.250 (0.207)	0.986 (0.280)	0.221 (0.037)	0.367 (0.058)	0.589 (0.042)	4.783 (0.345)
Mean Ratio for Control Group	5.287 (0.329)	6.054 (0.653)	6.785 (0.563)	5.433 (0.336)	5.647 (0.536)	6.044 (1.249)	5.804 (0.973)	7.638 (0.504)	5.829 (0.439)	5.482 (0.344)
Mann-Whitney Statistic	0.110	-1.670	-2.526	-0.527	-5.514	-3.969	-5.800	-5.800	-5.800	-1.494

Panel A: Return variances are computed for each firm each month. The cross-sectional median is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly medians. Variance ratios are computed for each firm each month, then cross-sectional medians are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly median ratios. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistic reported in row 7 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly median ratios are identical for cross-listed and control-group stocks.

Table 7 (cont.): Day-to-Night Variance Ratios

Panel B - Averages	Portfolio									
	(N^*, L)	(N^*, T)	(N^*, L, T)	U.S. Stocks	(L^*, N)	(L^*, N, T)	(T^*, N)	(T^*, N, L)	Foreign Stocks	Foreign & U.S. Stocks
Mean Overnight Variance for Cross-Listed Stocks (x1000)	0.194 (0.084)	0.296 (0.141)	0.204 (0.122)	0.202 (0.093)	0.286 (0.123)	3.061 (2.806)	0.718 (0.186)	0.547 (0.133)	0.646 (0.335)	0.248 (0.118)
Mean Daytime Variance for Cross-Listed Stocks (x1000)	0.567 (0.203)	0.469 (0.141)	0.898 (0.431)	0.632 (0.207)	0.324 (0.130)	2.754 (2.057)	0.170 (0.051)	0.158 (0.043)	0.510 (0.252)	0.621 (0.208)
Mean Overnight Variance for Control Group (x1000)	0.311 (0.118)	0.171 (0.085)	0.166 (0.092)	0.277 (0.099)	0.145 (0.066)	0.244 (0.158)	0.165 (0.067)	0.108 (0.058)	0.145 (0.070)	0.262 (0.094)
Mean Daytime Variance for Control Group (x1000)	0.789 (0.229)	0.602 (0.185)	0.396 (0.089)	0.713 (0.197)	0.411 (0.106)	0.907 (0.641)	0.482 (0.165)	0.430 (0.153)	0.478 (0.176)	0.684 (0.192)
Mean Ratio for Cross-Listed Stocks	7.773 (0.842)	4.970 (0.578)	9.532 (2.534)	7.993 (0.742)	1.769 (0.351)	7.683 (6.722)	0.248 (0.043)	0.491 (0.079)	1.606 (0.556)	7.389 (0.691)
Mean Ratio for Control Group	7.729 (0.920)	9.397 (1.441)	9.147 (0.717)	7.875 (0.847)	7.337 (0.617)	6.255 (1.227)	6.311 (0.907)	9.903 (0.772)	8.108 (0.588)	7.903 (0.771)
Mann-Whitney Statistic	0.220	-2.768	-2.109	0.154	-5.273	-3.412	-5.800	-5.800	-5.317	-0.967

Panel B: Return variances are computed for each firm each month. The cross-sectional average is then computed for each month. The means (standard errors) reported in rows 1 through 4 are computed from the distribution of these monthly averages. Variance ratios are computed for each firm each month, then cross-sectional averages are computed. The mean ratios (standard errors) reported in rows 5 and 6 are computed from the distribution of these monthly average ratios. Control groups contain non-cross-listed NYSE stocks that match those in the cross-listed portfolios on the basis of SIC code and firm size. The Mann-Whitney Statistic reported in row 7 is distributed approximately standard normal under the null hypothesis that the distributions of the monthly average ratios are identical for cross-listed and control-group stocks.

TABLE 8: Cross-Sectional Regression
Day-To-Night Variance Ratios

$$R^{dn}_{it} = \alpha_o + \alpha_1\ D1_{it} + \alpha_2\ D2_{it} + \alpha_3\ D3_{it} + \alpha_4\ D4_{it} + \alpha_5\ D5_{it} + \alpha_6\ D6_{it} + \alpha_7\ D7_{it} + \gamma\ OCT_t + \epsilon_{it}$$

α_o	α_1	α_2	α_3	α_4	α_5	α_6	α_7	γ	Adj. R^2
1.644	-0.020	-0.419	0.221	-1.681	-0.028	-3.077	0.150	-0.796	.275
(112.721)	(-0.917)	(-6.087)	(2.672)	(-24.489)	(-0.085)	(-22.062)	(0.923)	(-14.079)	

R^{dn}_{it} is the day-to-night variance ratio for stock i in month t. Each dummy variable relates to the primary and cross listings of stock i during month t. $D1_{it}$ equals one for a New York primary listing, and a London cross listing; and equals zero otherwise. $D2_{it}$ equals one for a New York primary listing, and a Tokyo cross listing; and equals zero otherwise. $D3_{it}$ equals one for a New York primary listing, and both Tokyo and London cross listings; and equals zero otherwise. $D4_{it}$ equals one for a London primary listing, and a New York cross listing; and equals zero otherwise. $D5_{it}$ equals one for a London primary listing, and both New York and Tokyo cross listings; and equals zero otherwise. $D6_{it}$ equals one for a Tokyo primary listing, and a New York cross listing; and equals zero otherwise. $D7_{it}$ equals one for a Tokyo primary listing, and both New York and London cross listings; and equals zero otherwise. OCT_t equals one if month t is October 1987, and equals zero otherwise.Ordinary least squares estimates are reported in the table. The t-statistics that appear in parentheses are adjusted for heteroskedasticity using White's heteroskedasticity-consistent estimate of the covariance matrix of the coefficient estimates. 7,224 observations.

Volatilitet, handelsmekanismer och internationell korsnotering

Litteraturen över New York-börsens (New York Stock Exchange/NYSE) mikrostruktur vidhåller att större volatilitet då börsen öppnas än när den stängs beror dels på att det är specialister, som öppnar den och då utnyttjar sin monopolställning, dels på att börsen före öppnandet varit stängd under en längre tid. Här separeras dessa två hypoteser genom att man skilt studerar aktier, som också noteras i London och Tokio. Amerikanska aktier som noteras i London och Tokio har inte varit så länge i avsaknad av notering som de som enbart noteras på NYSE.

Man går till väga så att man estimerar variansen i noteringen under öppningsminuterna och stängningsminuterna månadsvis. Man bildar kvoten av den förra och den senare variansen och räknar därefter medianerna av aktier i olika portföljer upplagda enligt om aktien även noteras i London eller Tokio.

Resultaten av undersökningen visar på att specialisters monopolställning vid öppnandet inte har någon betydelse. Den större volatiliteten då börsen öppnas kan helt förklaras av att order samlats på hög, vilket inte sker då börsen stänger. Korrigerar man för omsättningen kan man inte påvisa någon skillnad i volatilieten vid öppning och stängning.

I artikeln undersöks det också om korsnotering på en sekundär börs inverkar på volatiliteten under dagen och över natten. Här uppnås en generalisering av tidigare resultat. Amerikanska aktiers volatilitet under dagen är mycket större än utländska aktiers. Dessutom påträffas en assymmetri. Kors-notering av amerikanska aktier i Tokio minskar amerikanska aktiers volatilitet på NYSE, medan kors-notering i London inte gör det.

Ifall sjunkande volatilitet beror på assimilering av färsk information kunde följande slutsatser dras:

1) Informationsflödet till det noterade värdepapperspriset påskyndas av att värdepapperets primärmarknad är öppen,

2) Londonbörsen ringa inverkan på NYSE tillskrivs att den öppnas 4.30 New York-tid, då informationsflödet är svagt. Därför skulle NYSE inte fungera bättre om den öppnades tidigare än nu, men väl ifall öppethållningstiden skulle förlängas.

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