Multimarket Trading, Volume Dynamics, and Market Integration

Michael Halling

Pamela C. Moulton

Marios Panayides*

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* Halling is at University of Utah, michael.halling@business.utah.edu; Moulton is at Fordham Graduate School of Business, pmoulton@fordham.edu; and Panayides is at University of Utah, marios.panayides@business.utah.edu. We thank Leonce Bargeron, Shmuel Baruch, Hank Bessembinder, Tarun Chordia, Eric Hughson, Pankaj Jain, Avner Kalay, Aditya Kaul, Mike Lemmon, Shawn Thomas, Lenos Trigiorgis, George Nissiotis and seminar participants at the University of Cyprus, University of Pittsburgh, University of Utah, and the Northern Finance Association Meetings for helpful comments. We thank Bob Keays for excellent research assistance.

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Abstract

We examine the correlation between trading volume shocks in a firm's domestic and cross-listed shares as a novel measure of market integration. If markets were perfectly integrated, discretionary investors would view domestic and cross-listing markets as effectively constituting one large market. Multimarket trading by such investors engaging in either trade-splitting or arbitrage would lead to a high correlation of volume shocks on the markets. We find wide dispersion in the correlation of trading volume shocks across a large sample of cross-listed firms over two decades. These correlations are greatest for stocks traded in markets with more overlap in their trading hours, similar market structures, stronger enforcement of insider trading laws, and unconstrained short-sales. At the firm level, firms that are small, are technology-oriented, have more institutional investors, and have similar trading volume in their cross-listed and domestic shares have more integrated markets. These results provide support for both trade-splitting and arbitrage theories of multimarket trading.

1. Introduction

Whenever the stock of one firm is traded on multiple markets, as is the case for firms that list their shares on both their domestic and a cross-listing market, discretionary investors have a choice of where to trade.[1] The theoretical models of Pagano (1989), Chowdhry and Nanda (1991), and Menkveld (2008) show that investors' optimal choices may result in an equilibrium consisting of all trading concentrated in one market, most trading concentrated in one market, or substantial trading in both markets. In this paper we focus on the dynamics of trading volume in a multimarket setting, to better understand to what degree traders actively exploit multimarket environments and treat competing markets as one large market.[2]

Specifically, we investigate the extent to which trading volume shocks on one market correspond to volume shocks on the other market and how this relation is linked to multimarket trading. The models of Chowdhry and Nanda (1991) and Menkveld (2008) suggest that if there are non-discretionary liquidity traders in both markets, large liquidity traders and privately informed traders split their trades across markets and concentrate their trades during overlapping trading hours to minimize the price impact of their trades.[3] Furthermore, a central tenet of financial economics is that arbitrage, defined as "the simultaneous purchase and sale of equivalent securities in two different markets in order to profit from discrepancies in their price relationship" (Bodie, Kane, and Marcus (2002)), enforces the law of one price. These theories of multimarket trading suggest that trading volume shocks of cross-listed firms across markets should be perfectly positively correlated unless there are trading frictions. Such frictions would discourage or prevent investors from trading in both markets. We investigate the effect of market-level and firm-level trading frictions on the correlation of trading volume shocks in a multimarket setting.

To the extent that the correlations of trading volume shocks are driven by the same investors trading on both markets, the correlation of trading volume shocks between domestic and cross-listing markets provides a novel measure of market integration. Previous studies have

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[1] For evidence that investors view domestic and cross-listed stocks of the same firm as close substitutes, see JPMorgan (2003) and Moulton and Wei (2008).

[2] Baruch, Karolyi, and Lemmon (2007) and Halling, Pagano, Randl, and Zechner (2007) examine empirically the equilibrium distribution of trading across competing markets, a question which is related to but distinct from ours.

[3] Similar results are obtained in models with other constraints instead of non-discretionary liquidity traders; see, for example, Baruch, Karolyi, and Lemmon (2007).

shown that most domestic and cross-listing markets are highly integrated from a pricing perspective at both the daily and the intraday frequency; see, for example, Gagnon and Karolyi (2004) and Hupperets and Menkveld (2002). Our measure captures a different aspect of market integration: Do investors view the domestic and cross-listing markets as effectively constituting one big market? If so, a trading volume shock that occurs in one market should affect trading in both markets, leading to a perfect correlation between trading volume shocks in the two markets. If, on the other hand, investors view the two markets as separate or are unable to trade in more than one market, trading volume shocks in one market would be largely contained within that market, leading to little or no correlation between trading volume shocks in the two markets.

Our sample includes 361 firms from 24 countries that are cross-listed in the United States and covers the period 1980 to 2001. We first estimate a vector autoregression (VAR) model for each firm each year to estimate daily unexpected trading volume shocks in the domestic and cross-listing markets. The residuals from the VAR are our measures of daily trading volume shocks, and the correlation between the residuals from the domestic and cross-listing markets is our measure of market integration. The average correlation in our sample is 0.31, and 91 percent of the firm-year correlations are different from zero at the five percent level of significance. There is considerable dispersion among the trading volume correlations. It is this dispersion that we seek to explain by examining how trading frictions are related to the trading volume shock correlations cross-sectionally and over time.

We find that the degree to which trading volume shocks between domestic and cross-listing markets are correlated depends on both market-level and firm-level trading frictions. Stocks traded in markets with more overlapping trading hours, stronger enforcement of anti-insider trading laws, similar market design, and no short-sale constraints generally have higher correlations. At the firm level, stocks with more U.S. institutional investors, similar trading volume in the cross-listing and domestic shares, larger absolute yearly returns, and a technology orientation have more integrated markets. We find larger correlations of trading volume shocks for small and volatile firms, suggesting that a desire to minimize price impact, not only arbitrage trading, drives these correlations.

This paper adds to the literature in several ways. By analyzing a large sample of many firms over many years, we reveal a rich set of market- and firm-level determinants of multimarket integration. We explicitly evaluate the sources of variation in the level of market integration across markets as well as across firms. To our knowledge, this is the first paper to address these issues. For example, Menkveld (2008) tests his theoretical model empirically using 25 British and four Dutch stocks cross-listed on the New York Stock Exchange (NYSE). While he proxies for the fraction of non-discretionary traders on the NYSE, his study design does not allow for a broader analysis of market-level or firm-level frictions. Our findings suggest the importance of incorporating trading frictions in theoretical models of multimarket trading. Our study also has important implications for firms considering the value of cross-listing: If a firm's goal in cross-listing is to create a global trading environment for its shares, it would do well to examine the trading frictions of potential cross-listing venues. Our empirical proxy of market integration provides a way of measuring whether such a global trading environment is created. Finally, our results regarding market features that are instrumental in creating an integrated multimarket trading environment should be of interest to exchanges seeking to attract more cross-listings.

The organization of the paper is as follows. Section 2 reviews the theoretical literature and develops the research hypotheses. Section 3 discusses the data and methodology. Section 4 presents the results. Section 5 concludes.

2. Research Hypotheses

2.1 Sources of Correlated Trading Volume Shocks

There are three main potential explanations for correlated trading volume shocks between domestic and cross-listing markets. Two of these explanations rely on multimarket trading by the same traders. The same traders may be motivated to trade in both the domestic and cross-listing markets to minimize their trading costs (*price-impact minimization*)[4] or to profit from mispricings between securities in two markets (*arbitrage*). Trading volume shock correlations may also arise from positively correlated trading needs of investors who can trade on only one market, either domestic or cross-listing, (*correlated trading needs*). In this section we outline the theoretical and intuitive underpinnings for each potential explanation to develop our research hypotheses.

[4] Multimarket trading for price-impact minimization includes both individual order-splitting and, more generally, strategies involving execution of a single agent's trades on more than one market.

Several theoretical models of the equilibrium distribution of trading volume across markets are based on the intuition that traders are motivated to split their trades across markets to reduce their price impact. Pagano (1989) identifies a winner-takes-all equilibrium when there are no frictions protecting one market and an equilibrium in which two markets can coexist when there are trading frictions. Chowdhry and Nanda (1991) derive winner-takes-most equilibria when each market has a certain fraction of noise traders who have to trade in their home market. Both of these models assume that trading hours for the two competing markets coincide perfectly. Menkveld (2008) models the equilibrium distribution of trading between a domestic market and a cross-listing market with partially overlapping trading hours.[5] Menkveld combines Admati and Pfleiderer's (1988) intuition that traders tend to concentrate their trades during certain times with Chowdhry and Nanda's (1991) model of multi-market trading. He predicts that as long as there are some non-discretionary liquidity traders in both markets, discretionary liquidity traders and informed traders will split their trades across markets and concentrate their trades during overlapping trading hours. Price-impact minimization strategies should produce a positive correlation between trading volume shocks on the domestic and cross-listing markets. In a frictionless world where all trading is split across markets, the correlation would be expected to be one.

A central tenet of financial economics is that arbitrage enforces the law of one price, preventing equivalent securities from trading at different prices at the same time. Gagnon and Karolyi (2004) and Menkveld (2008) document that mispricings between the shares of the same firm trading in its domestic market and a cross-listing market occasionally occur. Gagnon and Karolyi (2004) also find that arbitrage is impeded by institutional and informational barriers that prevent arbitrageurs from fully eliminating mispricings between markets. In a frictionless world where all temporary mispricings could be efficiently arbitraged away, arbitrage trading would contribute to a positive correlation between trading volume shocks for cross-listed firms across markets.

The third potential explanation for correlated trading volume shocks across markets is that there are investors in each market who can trade only in their own market and their trading

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[5] For example, the London Stock Exchange is open from 8:00 to 16:30 Greenwich Mean Time (GMT) while the New York Stock Exchange is open from 14:30 to 21:00 GMT (9:30 to 16:00 Eastern time), producing a two-hour overlap.

needs are correlated.[6] Investors' correlated trading needs may arise from portfolio rebalancing, herding (as in Sias (2004)), or even simultaneous agreements to disagree (as in Hong and Stein (2003)). Note that while the price-impact minimization and arbitrage explanations for trading volume correlations arise from the same traders trading in both markets (i.e., multimarket trading), under correlated trading needs each investor trades on only one market; the key assumption is that these "captive" investors are motivated to trade on the same day.

We formulate the following hypotheses based on the intuition of how price-impact minimization, arbitrage, and correlated trading needs affect the correlation of trading volume shocks between domestic and cross-listing markets.

Hypothesis 1: Trading volume shocks in a firm's domestic stock market should be positively correlated with trading volume shocks in the cross-listing market. Such positive correlations may arise because of price-impact minimization, arbitrage, and correlated trading needs of captive investors.

Hypothesis 2: The correlation between trading volume shocks on the domestic and cross-listing markets should vary with the level of frictions between shares traded in the two markets if the correlation is driven by price-impact minimization and/or arbitrage.

In particular, we expect trading volume correlations to be lower when there are greater frictions between the domestic and cross-listing markets. For example, if trading in one market is more costly than trading in the other, the price-impact benefits of splitting trades across the two markets may be more than offset by the additional cost of trading in the more expensive market. If this were the case, traders would concentrate their trading in the cheaper market leading trading volume shocks to affect the expensive market far less than the cheaper market and producing lower trading volume shock correlations. Higher trading costs in the cross-listing and domestic markets combined may discourage arbitrage activity and therefore lead to lower trading volume shock correlations.

Market and firm-specific frictions should have different effects on trading that is due to price-impact minimization and arbitrage versus correlated trading needs. If trading volume shock correlations are due to correlated trading needs in fragmented markets or persistent price changes from informed trading in one market that cause investors in the other market to adjust

[6] Karolyi, Lee, and van Dijk (2008) present evidence on commonality in trading activity of individual stocks within one market.

their portfolios, trading frictions should not explain the differences in trading volume shock correlations.

To the extent that the correlation of trading volume shocks across domestic and cross-listing markets is explained by trading frictions, it also provides evidence on the level of integration between markets. This notion of market integration goes beyond arbitrage-free price integration, which has been shown to hold between most developed domestic and cross-listing markets by several studies; see, for example, Gagnon and Karolyi (2004) and Kim, Szakmary, and Mathur (2000). Here we consider market integration in terms of how volume shocks, caused by either liquidity shocks or information, spill across both markets as opposed to concentrating in one market.

In the following sections we develop market-level and firm-level measures (many of which proxy for trading frictions) that may affect the prevalence of price-impact minimization, arbitrage, and correlated trading needs between domestic and cross-listing markets. Table 1 summarizes the expected influence of each explanatory variable on trading volume shock correlations. In Section 3 we detail the data sources and calculation details for each measure.

[Table 1 Here]

2.2 Market-level Trading Frictions

Our first market-level explanatory variable is the trading hours overlap between the domestic and cross-listing markets. The more overlap there is between trading hours of the two markets, the easier it is for investors to split their trades and for arbitrageurs to exploit any mispricings that arise. Thus, we expect a positive relation between trading hours overlap and volume shock correlations.

Our second explanatory variable reflects relative trading costs. We use the market trading cost measure reported in Chiyachantana et al. (2004) to construct our trading cost variables. We expect a lower level of trading volume shock correlation if trading is significantly more costly on one market than on the other market, because such a cost differential would reduce the attractiveness of splitting trades across markets.

Our third measure of market-level frictions is the relative liquidity of the domestic and cross-listing markets. We expect that larger differences in market liquidity between the domestic and the cross-listing market result in lower correlations between volume shocks. We proxy for market liquidity differences by measuring the ratio of total trading volume (for all stocks) on the cross-listing market to total trading volume (for all stocks) on the domestic market.

If trading volume shock correlations are driven by arbitrage-based trading rather than price-impact minimization, we would not expect the correlations to depend on the differences in trading costs and liquidity between the markets, but rather on combined trading costs and combined liquidity. Thus we include as our fourth and fifth measures the sum of trading costs and the sum of trading volume across the domestic and cross-listing markets.

Our sixth measure of market-level frictions is the relative investor protection of the domestic and cross-listing markets. If one market provides less protection against insider trading (as a proxy for investor protection more generally), we expect investors to trade less there. As a consequence, we expect that trading volume shock correlations are higher once anti-insider trading laws have been enforced on both markets, as both trade-splitting for price-impact minimization and arbitrage trading would be more prevalent.

Our seventh measure of market-level frictions is the absence of short-sale constraints in the domestic market. Short-sale constraints render arbitrage very difficult or impossible, which can allow prices in the cross-listing and domestic markets to diverge. As a consequence, trade-splitting for price-impact minimization may also be more attractive when there are no short-sale constraints.

Our last measure of market-level frictions is the difference in market structure between the cross-listing and domestic markets. When one market has a traditional floor structure while the other is electronic, trade-splitters and arbitrageurs may find it more difficult to execute trades in both markets. The difference in market structure may also serve as a proxy for differential trading costs, as Jain (2005) documents that electronic trading enhances stock market liquidity.[7]

2.3 Firm-level Trading Frictions

There are several firm-level trading frictions that should be consequential for the trading volume shock correlations of a specific firm's domestic and cross-listed shares. To the extent that price-impact minimization drives volume shock correlations, firm-level proxies for price

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[7] We do not include foreign exchange volatility as a market-level friction because the foreign exchange market is among the most liquid markets in the world, particularly for the developed countries that are the home markets for most of our sample. When we include foreign exchange volatility as an additional explanatory variable as a robustness check, its coefficient estimate is insignificant and other coefficient estimates are unchanged.

impact should be related to volume shock correlations. To the extent that arbitrage activity drives volume shock correlations, firm characteristics that facilitate short-selling and reduce noise-trader risk should be related to volume shock correlations, since they reduce the barriers to arbitrage. In the following we discuss several empirical proxies and relate them to these alternative explanations for correlations in trading volume shocks as well as the possibility of correlated trading needs for captive investors in each market.

Our first set of explanatory variables captures firm characteristics that we expect to be related to both the price-impact minimization and arbitrage explanations for trading volume shock correlations, but with different directional predictions. Chiyachantana et al. (2004) find that price impact is largest for small firms, suggesting a negative relation between firm size and trading volume shock correlations as traders are more likely to split trades across markets when price impact is larger. In contrast, Jones and Lamont (2002) and D'Avolio (2002) document that small stocks are difficult to short, suggesting a positive relation between firm size and trading volume shock correlation as arbitrage trading should be more prevalent in larger stocks. Thus, the size variable may help us determine whether the observed correlations are mainly driven by price-impact minimization (negative coefficient) or arbitrage-based trading (positive coefficient).

A second firm-level characteristic that produces different predictions under price-impact minimization and arbitrage is idiosyncratic stock volatility. Domowitz et al. (2001) find that price impact is larger for stocks that have higher volatility, suggesting a positive relation between stock volatility and trading volume shock correlations as traders seek to minimize price impact by splitting their trades for the most volatile firms. In contrast, several papers (e.g., Wurgler and Zhuravskaya (2002), Ali, Hwang, and Trombley (2003), and Mendenhall (2004)) document that stocks with high levels of idiosyncratic risk are more difficult to arbitrage, suggesting a negative relation between the correlation of trading volume shocks and firm-level idiosyncratic volatility.

Our next set of explanatory variables captures firm characteristics that we expect to be related to both the price-impact minimization and correlated trading needs explanations for trading volume shock correlations. A large (positive or negative) yearly return could proxy for the potential gains to be earned from trading optimally and exploiting the multimarket framework. If those gains are large enough to overcome existing frictions, we expect to observe higher volume shock correlations in stocks with large yearly returns. Similarly, large yearly returns could lead to correlated trading volume shocks because investors in each market have to adjust their portfolios following persistent price changes. The influence of returns on volume shock correlations is expected to be positive under both the price-impact minimization and the correlated trading needs explanations.

Institutional ownership produces different predictions under the price-impact minimization and correlated trading needs explanations for correlated trading volume shocks. Institutional investors typically have more discretion about their trading location than retail investors, and thus are more likely to split their trades across markets. The price-impact minimization explanation would thus suggest that domestic and cross-listing market volume shocks are more correlated for firms owned predominantly by institutional investors (a positive coefficient), while the explanation based on correlated trading needs for non-discretionary investors (who are more likely to be retail investors) would suggest the opposite (a negative coefficient). We use the percentage of shares held by U.S. institutions and the number of U.S. institutions invested in a firm as proxies for institutional ownership.

The remaining explanatory variables relate most closely to the price-impact minimization explanation for correlated trading volume shocks across markets. A firm's liquidity on the domestic and the cross-listing market may influence the correlation of trading volume shocks, similar to the effect of market-wide liquidity. For example, if a stock is generally not actively traded in the cross-listing market, it should be relatively costly for investors to split their trades. The average trading volume in a market can also be interpreted as a proxy (albeit rough) for the number of non-discretionary liquidity traders in each market. For both reasons we expect trading volume shock correlations to be highest when a stock is actively traded in both markets, leading to a positive coefficient on the relative trading volume of the domestic and cross-listing markets.

The last set of firm-level variables addresses where price-relevant public information is generated for a specific stock.[8] This public information includes firm-specific information such as earnings announcements and industry information such as the performance of major competitors. In general, such information is revealed before or at the time that the domestic market opens, before the cross-listing markets in our sample open.[9] These information location

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[8] Chowdhry and Nanda (1991) acknowledge that the existence of information externalities including the timely dissemination of price information might play an important role.

[9] Ellul, Shin, and Tonks (2005) discuss the importance of the opening of markets, arguing that the market open performs an important information aggregation and price discovery function.

factors should affect trading volume shock correlations mainly through price-impact minimization, although if information revelation causes temporary price dislocations it could also boost arbitrage activity. If a firm's stock price depends to a large extent on the domestic market, we expect the correlation of trading volume shocks to be low, because when this information is revealed only the domestic market is open so investors can trade only on the domestic market – this suggests a negative coefficient on the stock return correlation to the domestic stock index. On the other hand, if a considerable amount of price-relevant information is revealed when the cross-listing market is open we expect volume shock correlations to be higher, as investors can trade on this information in both markets – this suggests a positive coefficient on the stock return correlation to the cross-listing market's stock index. Another measure of relative information revelation is the Baruch- Karolyi-Lemmon (BKL) measure, which is based on the difference in R-squared between regressions of cross-listed stock returns on domestic and cross-listing market index returns and regressions of cross-listed stock returns on only domestic market index returns (see Baruch, Karolyi, and Lemmon (2007)). We expect a positive coefficient on the BKL measure, as a higher BKL measure signals more firm-specific public information being revealed in the cross-listing market.

Two final firm-level explanatory variables that relate to the location of information production are the fraction of sales from foreign markets and the technology orientation of the firm. We expect that firms with more of their total sales coming from non-domestic markets have relatively more of their information revealed abroad, leading to a positive coefficient on the fraction of foreign sales. Pagano, Roell, and Zechner (2004) document that cross-listing in the U.S. has been especially attractive to technology-oriented companies. Further, Halling et al. (2007) find that technology-oriented companies are on average more successful in creating an active market in the U.S. (the cross-listing location for the stocks in our sample). A potential explanation for these empirical observations is the prevalence of U.S. firms in the technology sector. We expect that prices of technology-oriented cross-listed firms depend to a large extent on information revealed in the U.S. market, leading to higher trading volume shock correlations for technology-oriented firms. [10]

[10] While the type of cross listing (for example, American Depositary Receipt versus Global Share) is another possible friction, the vast majority of our sample cross-listed shares are ADRs, providing too little variation for meaningful analysis; see Moulton and Wei (2008).

3. Data and Methodology

3.1 Sample and Data

We begin with the home-market and cross-listed shares of all firms whose common stock is cross-listed on the New York Stock Exchange, NASDAQ, or the American Stock Exchange at any time between 1980 and 2001. Because the theoretical basis for both trade-splitting and arbitrage rely on simultaneous trading in the domestic and cross-listing markets, we include in our sample only firms for which domestic and cross-listing market trading hours overlap. Our sample is further limited to stocks for which daily trading volume and price data in both the domestic and the cross-listing market are available from Thompson Financial Datastream and Reuters Equity 3000, and both the domestic and cross-listed stocks have enough daily trading data to allow estimation. Our resulting sample includes 361 firms from 24 countries.

For each cross-listed company each day, we calculate the daily U.S. dollar volume on the domestic and the cross-listing market as the number of shares traded times the closing price, converting domestic-currency values to U.S. dollars at the daily closing foreign exchange rate from Thompson Financial Datastream and Reuters Equity 3000. By calculating volume in dollars rather than in shares, we automatically adjust for the American Depositary Receipt (ADR) ratio, since the ADR price reflects the number of domestic shares represented by the ADR.

We collect both market-level and firm-level explanatory variables to proxy for frictions between the domestic and cross-listing markets, as detailed in Section 2 and Table 1. All explanatory variables are measured annually and are derived from the following sources.

Market-level explanatory variables. Trading hours overlap (*Overlap*) is measured as the percentage of domestic market trading hours that overlap with cross-listing market trading hours, gathered from exchange websites. Trading cost differential (*TCostDiff*) is an indicator variable taking the value of one if the absolute difference between total trading costs on the domestic and cross-listing markets reported in Chiyachantana et al. (2004) is above the median value of market pairs, else zero. Our proxy for relative market liquidity (*MarketVolumeRatio*) is measured as the absolute difference between one and the ratio of total dollar trading volume on the domestic and cross-listing markets, from Thompson Datastream. Total trading costs across the domestic and cross-listing markets (*TCostComb*) is the sum of the total trading costs for domestic and cross-listing markets reported in Chiyachantana et al. (2004). Our proxy for total market liquidity across both markets (*MarketVolumeComb*) is measured as the sum of total dollar trading volume on the domestic and cross-listing markets, from Thompson Datastream. Protection against insider trading (*ITProtect*) in the domestic market is a dummy variable that equals one in year *t* if insider trading laws have been enforced in the home market during or before year *t*, and zero otherwise, as reported in Bhattacharya and Daouk (2002). Short-sale (*ShortSale*) is a dummy variable equal to one in year *t* if short sales are permitted in that market that year, else zero, as reported in Bris, Goetzmann, and Zhu (2007). Market design difference (*MktDesignDiff*) is a dummy variable that equals one in year *t* if electronic trading has been introduced in either the domestic market or the cross-listing market, but not both, before year *t*, as reported in Jain (2005).

Firm-level explanatory variables. The firm-level variables are calculated from data supplied by Thompson Datastream and Reuters except as noted here. Firm Size (*Size*) is measured as total assets in millions of dollars per year, from Global Vantage and Worldscope. Idiosyncratic volatility (*StockVolatility*) is measured as the volatility of the residuals in a regression in which stock returns are regressed on returns of the cross-listing and the domestic market shares. Absolute yearly stock return (*Return*) is calculated as the stock's home-currency log price change over the year. U.S. institutional ownership is measured by the percentage of shares held by U.S. institutional investors (*SharesUS*) and the number of U.S. institutional investors (*NumberUS*), from Thompson Financial Shareworld. The firm volume ratio (*FirmVolumeRatio*) is the absolute difference between one and the ratio of the firm's dollar trading volume on the cross-listing market to the domestic market. Stock return correlations to the domestic market index (*DomCorr*) and the cross-listing market index (*CLCorr*) in year *t* are calculated using weekly stock returns and domestic or cross-listing market index returns from year *t-2* to year *t*. Baruch-Karolyi-Lemmon information share measure (*BKLMeasure*) in year *t* is calculated using weekly stock returns and market index returns from year *t-2* to year *t*. Fraction of foreign sales (*ForSales*) is measured in percentage points, from Worldscope. Technology sector (*TechSec*) is a dummy variable that equals one for technology-oriented companies, else zero otherwise, based on SIC codes from GlobalVantage and Worldscope.

Table 2 reports summary statistics for trading volume and the explanatory variables for our sample of 361 cross-listed firms. Daily dollar trading volume is higher in the domestic market than in the cross-listing market for most countries, with notable exceptions including Ireland, Israel, and most Latin American countries.

[Table 2 Here]

3.2 Measuring Trading Volume Shock Correlations

The hypotheses we want to test most naturally apply to shocks in trading volume (unexpected trading volume) rather than to the simple level of trading volume. We use a Vector Autoregression (VAR) framework to model expected trading volume in one market as a function of past trading volume in both markets; the residual from each VAR captures the trading volume shocks, or unexpected volume, in that market. In particular, for each firm *i* each year, we estimate the following VAR from trading volume measured at the daily frequency, *t*:

$$TVol_{i,t}^{dom} = \alpha_i^{dom} + \sum_{k=1}^{K} \gamma_i^{dom,k} TVol_{i,t-k}^{dom} + \sum_{l=1}^{L} \beta_i^{CL,l} TVol_{i,t-l}^{CL} + \varepsilon_{i,t}^{dom} \tag{1}$$

$$TVol_{i,t}^{CL} = \alpha_i^{CL} + \sum_{k=1}^{K} \gamma_i^{CL,k} TVol_{i,t-k}^{CL} + \sum_{l=1}^{L} \beta_i^{dom,l} TVol_{i,t-l}^{dom} + \varepsilon_{i,t}^{CL}, \tag{2}$$

where $TVol_{i,t}$ is either the trading volume level (measured as the logarithm of dollar trading volume) or the trading volume change (measured as the logarithm of the ratio of day *t* to day *t-1* dollar trading volume). The superscript *dom* denotes the domestic market and the superscript *CL* denotes the cross-listing market. The appropriate numbers of lags, *K* and *L*, are determined per firm and per year using the Akaike Information Criterion (AIC). Note that we do not include stock returns in our VAR, since our ultimate goal is to explain not simply trading volume within each market but rather the correlation in trading volume shocks across markets. We expect such correlation to be related to returns. We thus include a return variable in the multivariate regressions to explain trading volume shock correlations across markets, in Section 4.3.2.

We are interested in whether a trading volume shock in one market is related to the trading volume shock in the other market on the same day. Our main variable of interest therefore is not simply the unexpected trading volume in each market, $\varepsilon_{i,t}$, but rather the contemporaneous correlation between the unexpected trading volumes in the two markets. We calculate yearly correlations between the unexpected trading volume in the domestic and the cross-listing markets, resulting in an unbalanced panel of correlations, with one correlation for each firm each year.

4. Results

In this section we first estimate VARs for each stock each year to measure the trading volume shocks in each market. We then calculate the correlations between trading volume shocks in the domestic and cross-listing markets. Finally, we analyze the bivariate and multivariate relations between trading volume shock correlations and explanatory variables related to price-impact minimization, arbitrage, and correlated trading needs.

4.1 Trading Volume Dynamics in the VARs

Table 3 reports average statistics for the VARs described in Equations (1) and (2). We model both the level of trading volume and change in trading volume, as described above, each firm each year. For brevity we report the coefficients for only the first lag of each variable; each model includes up to four lags, determined by the AIC.

[Table 3 Here]

Table 3 highlights several interesting characteristics of trading volume dynamics in a multimarket context. First, autocorrelation coefficients are positive (negative) in the models of daily levels (changes) of trading volume, reflecting in both sign and magnitude the mean-reverting pattern of trading volume. These average autocorrelation coefficients are similar for the domestic and cross-listing markets.

Second, cross-market correlation coefficients are on average smaller and less significant than autocorrelation coefficients and are positive in each equation. The positive mean coefficients imply that on average there are positive spillover effects between the two markets.

Third, the simple VARs perform reasonably well in explaining multimarket trading volume dynamics. On average, the VARs explain 22% (29%) and 21% (30%) of the variation of daily trading volume levels (changes) for the domestic and cross-listing markets. The VARs work somewhat better for the trading volume changes, as indicated by their higher mean R-squared and lower variation in R-squared. For this reason we focus on the trading volume changes in the remainder of the paper. We also report the results based on trading volume levels as a robustness check.

4.2 Trading Volume Shock Correlations

For each of the VARs (trading volume level and trading volume change), we calculate the correlation between daily residuals on the domestic and the cross-listing market. Since the VARs are estimated separately for each firm each year, this procedure results in a correlation measure between trading volume shocks in the two markets for each stock each year.

Table 4 summarizes these correlations by the percentage of overlap in the trading hours of the cross-listing to the domestic market. On average, the correlation between volume shocks in the two markets is 0.31, and it is generally increasing in the amount of overlap.[11] Overall, 91% of the correlations are significant at the 5% level.[12] We include all correlations in the following analyses; for robustness we also replicate our results using only the significant correlations (results available on request).

[Table 4 Here]

4.3 Drivers of Correlated Trading Volume Shocks

In this section we use the explanatory variables developed in Sections 2 and 3 to empirically determine to what extent price-impact minimization, arbitrage, and correlated trading needs explain the correlation of trading volume shocks across domestic and cross-listing markets.

4.3.1 Bivariate Results

The first column of Table 5 presents correlations between our measure of trading volume correlations (*TVolChange*) and the market-level and firm-level explanatory variables. All of the market-level variables (the first seven rows) display significant correlations with *TVolChange,* and the signs are all consistent with the predictions of price-impact minimization and arbitrage in Table 1.

[Table 5 Here]

Among the firm-level variables, the four variables with different directional predictions under alternative explanations for trading volume correlations all demonstrate significant correlations supporting price-impact minimization in this simple bivariate analysis. The correlation of trading volume shocks is smaller for larger firms (negative correlation) and larger for more volatile firms (positive correlation). Both results are consistent with the predictions of price-impact minimization and inconsistent with the predictions of arbitrage as the primary cause of trading volume correlations. Both measures of institutional ownership (*SharesUS* and *NumberUS*) show that the correlation of trading volume shocks is higher for firms with greater

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[11] In separate tests, we examined the correlation of trading volume shocks for markets with no overlapping trading hours. Consistent with the theoretical predictions that the correlations are driven by simultaneous trading (trade-splitting and arbitrage), the non-overlapping markets exhibit correlations that are much lower and less significant.

[12] Significance is determined using Fisher's z-transformation. If c denotes the correlation and n denotes the degrees of freedom, then the test statistic $t = n^{1/2} \times \ln[(1+c)/(1-c)]$ is distributed approximately N(0,1).

institutional ownership (positive correlation), again consistent with the predictions of price-impact minimization but inconsistent with the predictions of correlated trading needs for captive investors in each market. *Return* exhibits a positive correlation, consistent with both price-impact minimization and correlated trading needs. The remaining variables all exhibit correlations consistent with the predictions of price-impact minimization in Table 1. Because of multicollinearity between a stock's return correlation to the domestic stock index and its correlation to the cross-listing market's stock index, we include only the correlation with the cross-listing market's stock index in our multiple regression analysis below.

4.3.2 Multivariate Results

We now move beyond the simple correlation analysis to examine how the explanatory variables related to price-impact minimization, arbitrage, and correlated trading needs affect trading volume shock correlations in a multivariate framework. We estimate the following equation using a random effects regression with robust standard errors:[13]

$$\begin{aligned} TVolCorr_{i,t} &= \alpha + \sum_{j=1}^{8} \beta_j MktLevelVar_{i,t,j} + \sum_{j=1}^{10} \gamma_j FirmLevelVar_{i,t,j} \\ &\quad + \lambda CLAge_{i,t} + \sum_{j=1}^{21} \delta_j Year_{t,j} + \varepsilon_{i,t}, \end{aligned} \qquad (3)$$

where $TVolCorr_{i,t}$ is the trading volume shock correlation (based on changes, *TVolChange*, or levels, *TVolLevel*) for stock *i* in year *t*, *MktLevelVar* is the set of market-level variables in Table 1, *FirmLevelVar* is the set of firm-level variables in Table 1, *CLAge* is the number of years since the firm was initially cross-listed, and *Year* is a calendar-year dummy variable. All explanatory variables except dummy variables are scaled by their standard deviations, so coefficient estimates provide a sense of the explanatory variables' relative impact. We also estimate the regression with subsets of the explanatory variables.[14]

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[13] Estimations from a pooled OLS regression with year fixed effects and Rogers standard errors clustered on firm, as in Peterson (2007), and a pooled OLS regression with standard errors double-clustered on firm and year, as in Thompson (2006), yield qualitatively similar results, which are available on request.

[14] As robustness checks, we also run a panel regression based on a subsample excluding Canada firms (approximately 50% of the full sample) and separate cross-sectional regressions each year. Estimations yield qualitatively similar results, which are available on request.

The results from estimating Equation (3) are presented in Table 6. Panel A contains the results using trading volume change correlation, *TVolChange*, as the dependent variable, while Panel B contains the results using trading volume level correlation, *TVolLevel*, as the dependent variable. Specification 1 focuses on the market-level explanatory variables. The significantly positive coefficient estimates on trading hours overlap and short sales and negative coefficient estimate on market design difference are consistent with the predictions of both price-impact minimization and arbitrage, while the significantly negative coefficient on the market volume ratio supports the price-impact minimization explanation. The remaining coefficients are consistent with the sign predictions in Table 1, but they are not significant at conventional levels. This specification, which includes only market-level explanatory variables, explains 28% of the variation in the correlation of trading volume shocks between domestic and cross-listing markets.

[Table 6 Here]

Specifications 2 and 3 focus on the firm-level explanatory variables. Because foreign sales is a sparsely-populated variable, we exclude it in Specification 3, which expands the number of firm-year observations by 40%. Excluding foreign sales as an explanatory variable does not change the signs of any other coefficient estimates, although it does alter their significance. The two explanatory variables for which price-impact minimization and arbitrage explanations of correlated trading volume predict opposite signs suggest that in aggregate price-impact minimization carries the day: firm size is negatively related to trading volume correlation, and idiosyncratic stock volatility is positively related to trading volume correlation. We find only weak support for the correlated-trading-needs explanation: The significantly positive coefficient on stock return supports both the price-impact minimization and correlated-trading-needs explanations. The significantly positive coefficients on the measures of U.S. institutional ownership (*SharesUS* and *NumberUS*), in contrast, are consistent only with price-impact minimization but not with correlated trading needs of captive investors, who are likely to be retail rather than institutional investors. The remaining variables all bear coefficient estimates that are consistent with the directional predictions of the price-impact minimization explanation, with all but two significant at conventional levels. Interestingly, firm-level variables alone explain about the same amount of variation in correlations that market-level variables alone do: R-squared is 27% for Specification 3 versus 28% for Specification 1.

Specification 4 includes market-level and firm-level explanatory variables, omitting the foreign sales variable to maximize the sample size. The results from the first three specifications are consistent with those in the full specification, with market-level variables generally supporting both the price-impact minimization and arbitrage explanations, while firm-level variables generally provide sharper support for price-impact minimization as the dominant explanation for correlated trading volume shocks in domestic and cross-listing markets. Among the market-level variables, the trading hours overlap, short sale, and market design difference variables are the most consequential for trading volume correlations. A one-standard-deviation increase in trading hours overlap increases the trading volume shock correlation by 0.09 on average, more than 25 percent of the average correlation of 0.31. If the domestic market eliminates short-sale constraints, the correlation of trading volume shocks is expected to increase by 0.05. A difference in market design creates statistically significant frictions in the integration of the two markets and decreases the correlation of trading volume shocks by about 0.03. Among the firm-level variables, the number of U.S. institutional investors and the firm's technology orientation are the most consequential for trading volume correlations. If a cross-listed firm succeeds in attracting 63 more U.S. institutional investors (one standard deviation), it is expected to raise the correlation of trading volume shocks on the domestic and cross-listing market by 0.04. On average, the trading volume shocks of technology firms are 0.08 more correlated than non-technology firms.

A key goal of this paper is to disentangle the sources of the correlation between trading volume shocks in domestic and cross-listing markets. In section 2.1, we identify three potential causes of correlated volume shocks: price-impact minimization, arbitrage, and correlated trading needs of captive investors. Our empirical results strongly suggest that the correlations are driven by price-impact minimization. At the market level, differences in trading costs seem to play a more important role than total trading costs in explaining volume shock correlations. At the firm level, size receives a negative coefficient and idiosyncratic volatility a positive coefficient. Both firm-level and market-level coefficients are consistent with the price-impact minimization explanation but not with the arbitrage explanation. However, it is not our contention that no arbitrage trading occurs; on the contrary, the existence of arbitrage trades is a prerequisite to keeping prices efficient and enabling investors to engage in trade splitting for price-impact minimization. Furthermore, the importance of short selling suggests that arbitrage plays a role. The fact that many of our proxies for frictions have explanatory power for the trading volume correlations also represents evidence that these correlations are related to investors trading on both markets, rather than correlated trading needs by captive investors trading in distinct markets.

Our multivariate analysis also provides an interesting perspective on the role of time in market integration. Table 6 shows that the number of years since a firm was cross-listed has a weakly positive impact on the trading volume correlation between markets. This suggests that the trading volume on the domestic and the cross-listing market is more integrated for more mature cross-listings, all else equal. Another dimension of time is calendar time. Figure 1 depicts the coefficients for the calendar-year fixed effects from Specification 4 with the trading volume change as dependent variable; other specifications yield similar results. Not surprisingly, there is a positive trend in the trading volume correlations, suggesting that market integration increases over our sample period.[15] Since we control for this time trend in our econometric specifications, our empirical results explain the trading volume correlations in excess of the pure time trend.

[Figure 1 Here]

5. Conclusion

We use the residuals from vector autoregressions to measure trading volume shocks in the domestic and cross-listed trading of 361 firms over a 22-year period. The correlations between domestic and cross-listed trading volume shocks provide a measure of market integration that is new to the literature. If markets were perfectly integrated, theory suggests that investors would spread their trades across markets as if they constituted one big market and exploit temporary mispricings through arbitrage trading, leading to a perfect correlation between volume shocks on the domestic and cross-listing markets. Instead, we find a wide variation in correlations and thus the degree of integration between markets. We further show that the variation in integration is related to a number of market-level and firm-level trading frictions, suggesting that the trading volume shock correlations are not caused by correlated trading needs of captive traders in both markets but rather by traders who are active on both markets, in pursuit of price-impact minimization or arbitrage.

These results have potentially important implications for firms considering cross-listing. If a firm's goal is to provide a more global trading environment, its ability to achieve a well-integrated domestic and cross-listing market depends on the characteristics of the two markets and the specific firm. The mere fact that markets in general have become more integrated over

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[15] See Bekaert, Harvey, Lundblad, and Siegel (2008) for evidence on increasing market integration using a valuation-oriented framework.

the past quarter century – due to technological innovation, for example – does not necessarily ensure that a firm's investors will experience the domestic and the cross-listing market as being perfectly integrated.

Our results also have potential implications for the competition of exchanges for cross-listings and trading volume. Our analysis suggests that overlapping trading hours, absence of short-sale constraints, and protection against insider trading are important drivers for the level of market integration.

Finally, our results suggest several avenues for future research. An increasing number of stocks are traded on multiple markets, not only via international cross-listings but also through direct trading of the same stock on multiple venues. Thus all market participants, including issuers, traders, and providers of trading services, must deal with issues of market integration across multiple trading platforms. Our study sheds light on the frictions that affect integration for firms with domestic and cross-listed shares, but similar questions of market integration and frictions exist whenever securities are traded in multiple markets or trading systems.

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Table 1. Explanatory Variables and Predicted Signs

Empirical measure (*abbreviation*)	Predicted effect on trading volume correlation		
	Price-Impact Minimization	Arbitrage	Correlated Trading Needs
Market-Level			
Trading hours overlap (*Overlap*)	+	+	None
Difference of trading costs in domestic and cross-listing market (*TCostDiff*)	–	None	None
Log of absolute value of one minus ratio of total trading volume on cross-listing market to domestic market (*MarketVolumeRatio*)	–	None	None
Sum of trading costs on domestic and cross-listing markets (*TCostComb*)	None	–	None
Sum of total trading volume on domestic and cross-listing markets (*MarketVolumeComb*)	None	+	None
Protection against insider trading in the domestic market (*ITProtect*)	+	+	None
Short sales permitted (*ShortSale*)	+	+	None
Market design different (*MktDesignDiff*)	-	-	None
Firm-Level			
Log of firm size (*Size*)	–	+	None
Idiosyncratic volatility (*StockVolatility*)	+	–	None
Absolute yearly stock return (*Return*)	+	None	+
U.S. institutional ownership (*SharesUS, NumberUS*)	+	None	–
Log of absolute value of one minus ratio of firm's dollar trading volume on cross-listing market to domestic market (*FirmVolume Ratio*)	–	None	None
Stock return correlation with domestic market index (*DomCorr*)	–	None	None
Stock return correlation with cross-listing market index (*CLCorr*)	+	None	None
BKL incremental information measure (*BKLMeasure*)	+	None	None
Fraction of sales from foreign markets (*ForSales*)	+	None	None
Technology sector (*TechSec*)	+	None	None

Table 2. Cross-Sectional Summary Statistics

This table summarizes our dependent and independent variables across home markets. Means are calculated in two steps: first, by averaging the variables over time for each firm; second, by averaging firm means within each country. The sample period covers 1980 to 2001, but not all firms are either cross-listed or observed during the entire period. Panel A summarizes our market-based variables. For the variable "Anti-Insider Trading Law Enforcement" we report the fraction of years in the sample before which anti-insider trading laws have been enforced. For "NoSSCons" we report the fraction of years where short-selling was possible (i.e., no short-selling constraints were in place). The column "Electronic Market" includes the year when the market became electronic (see Jain (2005)). Panel B summarizes our firm-specific variables. The table reports mean daily values for the domestic and the foreign trading volume in USD. For the remaining variables means are calculated across years per home market. Total assets are reported in Million USD.

Panel A: Market Characteristics

Home Market	Overlap	DiffCost	TotCost	MarketVolRatio	ProtectIT	ShortSale	Electronic Market
Argentina	6.00	0.36	1.83	120.20	0.91	0.40	1995
Belgium	2.00	0.59	1.99	321.85	1.00	1.00	1996
Brazil	6.50	0.44	1.90	14.88	1.00	1.00	1990
Canada	6.50	0.33	1.99	0.96	1.00	1.00	1977
Chile	6.50			154.56	0.80	0.00	1989
Colombia	2.50			369.60	0.00	0.00	1996
Denmark	1.50	0.05	1.63	445.53	0.69	1.00	1988
Finland	1.83	2.12	3.57	256.37	1.00	0.56	1988
France	2.00	0.38	1.72	20.68	1.00	1.00	1986
Germany	4.50	0.37	1.77	61.79	0.93	1.00	1991
Ireland	2.00	0.90	2.18	88.03	0.00	1.00	2000
Israel	0.50			327.87	1.00	0.00	1997
Italy	2.00	0.51	2.04	62.39	0.74	1.00	1994
Mexico	6.50	0.36	1.84	12.02	0.00	1.00	1996
Netherlands	2.00	0.17	1.75	18.45	0.71	1.00	1994
Norway	1.00	0.30	1.67	329.48	0.93	0.86	1988
Peru	4.00			662.11	1.00	0.00	1995
Portugal	3.00	0.30	1.72	447.26	0.00	1.00	1991
South Africa	0.50	0.31	2.00	10.61	0.00	1.00	1996
Spain	2.00	0.21	1.85	56.92	0.33	0.83	1989
Sweden	2.00	0.75	2.35	150.02	0.78	0.74	1989
Switzerland	2.00	0.22	1.68	36.68	1.00	1.00	1996
UK	2.00	0.54	2.16	6.07	1.00	1.00	1997
Venezuela	4.50			945.79	0.00	0.00	1992
Total	4.52	0.38	1.99	40.69	0.89	0.92	

Panel B: Company Characteristics

Home Market	Number of Firms	Domestic Trading Volume in USD	Foreign Trading Volume in USD	DomCorr	CLCorr	BKLMeasure	ForSales in %	TechSec	Size (Total Assets)	SharesUS	NumberUS	FirmVolumeRatio	Return in %	StockVolatility
Argentina	5	1,157	10,859	0.73	0.33	1.30	3	0.43	6,008	0.09	49	10.69	-0.09	0.04
Belgium	1	18,655	415	0.34	0.17	0.54		0.00	9,378	0.02	3	0.02	0.12	0.04
Brazil	2	4,601,056	99,542	0.54	0.28	1.69	0	0.08	11,160	0.00	37	3490.07	-0.17	0.11
Canada	186	3,237	2,589	0.28	0.20	2.01	50	0.18	4,718	0.08	21	2.49	-0.10	0.08
Chile	12	448	972	0.50	0.22	1.43	27	0.00	3,225	0.02	17	3.49	-0.07	0.06
Colombia	1	55	267		-0.01			0.00	3,343	0.23	14	7.09	0.17	
Denmark	2	7,560	973	0.40	0.21	2.51	59	0.00	2,385	0.04	33	14.07	-0.11	0.06
Finland	2	171,978	170,942	0.73	0.31	0.91	50	0.00	10,260	0.32	276	1.13	0.37	0.03
France	14	41,772	7,361	0.36	0.26	2.00	61	0.16	40,610	0.10	29	1.03	0.03	0.06
Germany	6	245,103	7,319	0.41	0.23	1.17	45	0.13	43,890	0.06	23	0.36	-0.02	0.05
Ireland	4	4,589	26,452	0.49	0.41	5.78	73	0.25	4,803	0.23	131	15.45	-0.17	0.06
Israel	15	944	4,164	0.58	0.32	1.25	52	0.32	1,075	0.06	19	5.83	-0.06	0.05
Italy	5	67,699	1,281	0.54	0.24	1.38	52	0.11	15,670	0.03	29	0.24	0.02	0.04

Home Market	Number of Firms	Domestic Trading Volume in USD	Foreign Trading Volume in USD	DomCorr	CLCorr	BKLMeasure	ForSales in %	TechSec	Size (Total Assets)	SharesUS	NumberUS	FirmVolumeRatio	Return in %	StockVolatility
Mexico	6	1,195	1,784	0.55	0.27	1.29	22	0.00	1,956	0.01	7	5.36	-0.12	0.06
Netherlands	17	50,775	14,103	0.45	0.33	2.58	64	0.09	38,950	0.07	41	1.20	0.05	0.04
Norway	4	8,389	2,609	0.59	0.29	1.67	66	0.00	8,308	0.10	48	0.36	-0.02	0.05
Peru	3	895	2,477	0.42	0.12	0.94	8	0.33	4,254	0.00	0	2.51	-0.31	0.06
Portugal	1	14,926	392	0.50	0.03	3.79		0.00	13,710	0.00	0	0.03	-0.11	0.03
South Africa	13	4,029	1,195	0.41	0.00	1.89	3	0.00	1,572	0.00	3	1.06	-0.03	0.11
Spain	3	43,853	3,938	0.61	0.30	1.17	26	0.00	55,480	0.05	65	0.24	0.08	0.03
Sweden	7	34,155	16,214	0.57	0.30	1.30	81	0.38	7,467	0.08	45	0.45	0.05	0.05
Switzerland	2	3,269	407	0.30	0.26	2.68	76	0.40	933	0.02	3	0.12	-0.09	0.06
UK	48	40,028	6,124	0.37	0.26	2.11	59	0.25	24,150	0.04	54	0.54	0.01	0.05
Venezuela	2	217	684	0.45	0.12	1.11	14	0.00	424	0.00	0	4.66	-0.11	0.09
Total	361	40,970	5,606	0.36	0.23	1.95	51	0.17	12,050	0.06	30	18.80	-0.05	0.07

Table 3. Summary of VAR Results

The table reports equally-weighted average statistics for the VAR estimated for the domestic and the foreign trading volume of each firm each year. The dependent variables are the log of domestic dollar trading volume (Ln_Dom_Vol) and the log of foreign dollar trading volume (Ln_For_Vol) in the left half of the table, and the log of the ratio of today's to yesterday's domestic dollar trading volume (Ln_Dom_VChg) and the log of the ratio of today's to yesterday's foreign dollar trading volume (Ln_For_VChg) in the right half of the table. We report average coefficients and average p-values for the first lags only.

		Ln_Dom_Vol		Ln_For_Vol			Ln_Dom_VChg		Ln_For_VChg	
		Mean	**SD**	**Mean**	**SD**		**Mean**	**SD**	**Mean**	**SD**
$Ln\_Dom\_Vol_{-1}$	**Coef**	0.29	0.15	0.07	0.19	**$Ln\_Dom\_VChg_{-1}$**	-0.57	0.14	0.04	0.32
	P-Val	0.07	0.18	0.39	0.31		0.01	0.05	0.44	0.30
$Ln\_For\_Vol_{-1}$	**Coef**	0.10	0.13	0.29	0.16	**$Ln\_For\_VChg_{-1}$**	0.07	0.13	-0.58	0.14
	P-Val	0.31	0.31	0.08	0.19		0.37	0.31	0.00	0.04
R-Squared		0.22	0.16	0.21	0.16		0.29	0.09	0.30	0.09

Table 4. Correlation of Residuals by Overlap of Trading Hours

This table reports average correlations and standard deviations across markets with different trading-hours overlaps (in percent of the domestic trading hours). The correlations are yearly correlations and are calculated from the daily residuals of VARs. We report correlations based on VARs with two different dependent variables – the log of the ratio of day *t* to day *t-1* trading volume (TVolChange) and the log of dollar trading volume (TVolLevel). The column "Sig 5%" reports the percentage of trading volume shock correlations that are significantly different from zero at the 5% level.

Percentage	**TVolChange**				**TVolLevel**			
Overlap	**Firms**	**Mean**	**SD**	**Sig 5%**	**Firms**	**Mean**	**SD**	**Sig 5%**
10	133	0.17	0.12	80%	142	0.20	0.12	83%
20	43	0.17	0.12	81%	44	0.20	0.11	91%
30	780	0.22	0.13	87%	797	0.23	0.13	90%
40	5	0.08	0.13	80%	5	0.10	0.12	60%
50	27	0.17	0.14	81%	27	0.18	0.12	78%
80	8	0.20	0.11	88%	8	0.21	0.09	88%
90	74	0.31	0.14	92%	75	0.31	0.12	95%
100	1,261	0.40	0.18	95%	1,310	0.41	0.17	96%
Total	2,331	0.31	0.18	91%	2,408	0.33	0.18	93%

Table 5. Correlation Matrices

This table summarizes correlations between dependent (shaded column) and independent variables. Bold correlations indicate correlations that are significantly different from zero at the 5% level. The abbreviations of the explanatory variables are explained in Table 1.

	TVolChange	Overlap	DiffCost	TotCost	MarketVolumeRatio	MarketVolumeComb	ProtectIT	ShortSale	MktDesignDiff	DomCorr	CLCorr	BKLMeasure	ForSales	TechSec	Size	SharesUS	NumberUS	FirmVolumeRatio	Return	StockVolatility
Overlap	**0.50**	1.00																		
DiffCost	**-0.12**	**-0.16**	1.00																	
TotCost	**-0.07**	-0.04	**0.89**	1.00																
MarketVolumeRatio	**-0.35**	**-0.59**	**0.09**	**-0.09**	1.00															
MarketVolumeComb	**0.10**	**0.05**	**-0.41**	**-0.63**	**0.11**	1.00														
ProtectIT	**0.22**	**0.31**	0.00	**-0.05**	**-0.30**	**0.23**	1.00													
ShortSale	**0.08**	**0.06**	**-0.25**	**-0.19**	**-0.59**	-0.01	**0.13**	1.00												
MktDesignDiff	**-0.11**	0.00	**-0.05**	0.01	**0.10**	**-0.06**	**-0.10**	**-0.12**	**1.00**											
DomCorr	**-0.16**	**-0.29**	**0.16**	**0.10**	**0.44**	**-0.18**	**-0.25**	**-0.30**	**0.24**	1.00										
CLCorr	0.04	**-0.10**	-0.01	**-0.08**	**0.14**	0.03	**0.12**	-0.04	0.00	**0.66**	1.00									
BKLMeasure	**0.14**	-0.01	**-0.08**	**-0.10**	**-0.05**	**0.04**	0.02	**0.10**	**-0.12**	0.01	**0.28**	1.00								
ForSales	**0.08**	**-0.09**	**0.06**	0.02	0.01	0.04	**0.19**	**0.14**	**-0.09**	-0.03	**0.11**	**0.07**	1.00							
TechSec	**0.18**	0.01	0.03	0.03	-0.03	**0.07**	**0.11**	-0.01	**-0.18**	-0.01	**0.17**	**0.07**	-0.04	1.00						
Size	**-0.26**	**-0.41**	**0.17**	**0.15**	**0.29**	**-0.15**	**-0.12**	-0.03	**0.23**	**0.53**	**0.33**	**-0.07**	**0.10**	**-0.11**	1.00					
SharesUS	**0.17**	**0.07**	**0.07**	0.01	**-0.06**	**0.09**	**0.09**	0.02	**0.07**	**0.08**	**0.15**	**0.12**	**0.14**	-0.01	**0.08**	1.00				
NumberUS	**0.14**	**-0.16**	**0.07**	0.00	**0.09**	**0.05**	**0.06**	0.03	**0.09**	**0.28**	**0.24**	**0.06**	**0.18**	**0.11**	**0.35**	**0.48**	1.00			
FirmVolumeRatio	**-0.08**	**0.10**	**-0.04**	**-0.06**	**0.07**	**0.09**	0.02	**-0.13**	-0.02	**-0.06**	0.01	**0.08**	-0.01	**0.12**	**-0.16**	0.03	**-0.04**	1.00		
Return	**0.20**	**0.12**	**-0.11**	**-0.12**	**-0.09**	**0.18**	**0.07**	**0.06**	**-0.19**	**-0.23**	**-0.09**	**0.04**	0.02	**0.10**	**-0.30**	-0.03	**-0.10**	**0.09**	1.00	
StockVolatility	**0.13**	**0.13**	**-0.06**	**-0.05**	**-0.11**	0.01	0.03	**0.04**	**-0.18**	**-0.32**	**-0.20**	-0.03	-0.02	0.01	**-0.27**	**-0.08**	**-0.12**	**0.08**	**0.21**	1.00

Table 6. Multivariate Regressions

This table presents the coefficient estimates and t-statistics (in parentheses) from multivariate regressions of correlations of trading volume shocks on the explanatory variables defined in Table 1. In Panel A the dependent variable is the correlation of trading volume shocks from the VAR using daily trading volume changes; in Panel B the dependent variable is the correlation of trading volume shocks from the VAR using daily trading volume levels. All variables except dummy variables are normalized by their standard deviations. Each specification controls for calendar-year fixed effects, and t-statistics are based on robust standard errors.

Panel A. Dependent Variable = TVolChangeCorr

	Spec. 1	Spec. 2	Spec. 3	Spec. 4
Overlap	0.07 (5.63)			0.09 (7.00)
TCostDiff	-0.02 (-1.08)			-0.03 (-1.85)
TCostComb	-0.01 (-0.48)			0 (0.22)
MarketVolumeRatio	-0.02 (-1.97)			-0.02 (-1.21)
MarketVolumeComb	0.04 (0.48)			-0.08 (-0.93)
ITProtect	0.02 (1.48)			0.01 (0.88)
ShortSale	0.05 (2.01)			0.05 (2.31)
MktDesignDiff	-0.03 (-3.16)			-0.03 (-3.09)
CLCorr		0.01 (1.18)	0.01 (1.32)	0.00 (0.71)
BKLMeasure		0.01 (1.89)	0.01 (2.69)	0.01 (2.27)
TechSec		0.07 (3.53)	0.06 (2.52)	0.08 (4.47)
Size		-0.04 (-4.58)	-0.03 (-3.54)	-0.01 (-1.21)
SharesUS		0.01 (2.48)	0.01 (2.37)	0.01 (2.35)
NumberUS		0.04 (7.05)	0.03 (5.19)	0.04 (7.37)
FirmVolumeRatio		-0.03 (-7.49)	-0.03 (-5.81)	-0.03 (-7.46)
StockVolatility		0.02 (1.21)	0.05 (2.40)	0.01 (0.96)
Return		0.02 (4.47)	0.02 (5.02)	0.02 (4.66)
CLAge		0.00 (0.39)	0.01 (1.23)	0.01 (1.27)
ForSales			0.01 (1.35)	
Constant	-0.47 (-0.33)	0.25 (4.41)	0.12 (2.50)	1.05 (0.89)
R-Squared	0.28	0.22	0.27	0.44
Firms	315	285	231	259
Firm Years	2175	1747	1260	1621

Panel B. Dependent Variable = TVolLevelCorr

	Spec. 1	Spec. 2	Spec. 3	Spec. 4
Overlap	0.07			0.09
	(5.73)			(7.09)
TcostDiff	-0.00			-0.01
	(-0.02)			(-0.50)
TcostComb	-0.01			-0.00
	(-0.80)			(-0.36)
MarketVolumeRatio	-0.03			-0.01
	(-2.31)			(-0.90)
MarketVolumeComb	0.02			-0.05
	(0.35)			(-0.66)
ITProtect	0.02			0.02
	(1.54)			(1.42)
ShortSale	0.04			0.04
	(1.82)			(1.68)
MktDesignDiff	-0.02			-0.02
	(-2.41)			(-2.78)
CLCorr		0.00	0.01	0.00
		(1.02)	(1.14)	(0.50)
BKLMeasure		0.01	0.01	0.01
		(1.65)	(2.73)	(1.90)
TechSec		0.07	0.07	0.07
		(3.42)	(2.94)	(4.34)
Size		-0.04	-0.03	-0.01
		(-5.04)	(-3.49)	(-1.18)
SharesUS		0.01	0.01	0.01
		(2.56)	(2.64)	(2.43)
NumberUS		0.04	0.03	0.04
		(6.92)	(5.08)	(6.92)
FirmVolumeRatio		-0.03	-0.03	-0.03
		(-7.88)	(-5.22)	(-7.27)
StockVolatility		0.01	0.04	0.01
		(1.51)	(2.14)	(1.59)
Return		0.02	0.02	0.02
		(4.57)	(5.10)	(4.71)
CLAge		0.00	0.01	0.01
		(0.50)	(1.32)	(1.47)
ForSales			0.01	
			(1.13)	
Constant	-0.21	0.25	0.10	0.75
	(-0.16)	(2.87)	(2.17)	(0.67)
R-Squared	0.28	0.24	0.28	0.45
Firms	320	288	235	262
Firm Years	2245.00	1790.00	1287.00	1659.00

Figure 1   Coefficients of Calendar-Year Dummies

This figure reports the estimated coefficients (indicated by the dots) and 95% confidence intervals of the calendar-year dummies estimated from a Random Effects Model including all variables, except foreign sales to maximize observations, and using the TVolChangeCorr specification.