

Multi-Market Trading and Liquidity: Theory and Evidence[★]

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Abstract

We develop and test a new model of multi-market trading to explain the differences in the foreign share of trading volume of internationally cross-listed stocks. The model derives an equilibrium which predicts that, under fairly general conditions, the distribution of trading volume across exchanges competing for order flow is related to the correlation of the cross-listed asset returns that arise in the respective markets. That is, volume is proportionally higher on the exchange in which the cross-listed asset returns have greater correlation with returns of other assets traded on that market. We test this prediction with weekly stock returns and volume data on 251 non-U.S. stocks cross-listed on major U.S. exchanges. We find strong empirical support for the prediction, even after controlling for potential endogeneity effects as well as a host of other firm-specific, issue-specific and country-level factors.

JEL classification: F30, G14, G15.

Keywords: International finance; cross-listings; trading; liquidity

Current Version: February 21, 2006

[★] We thank an anonymous referee and the editor as well as seminar participants at the Università di Bologna, University of Utah, Georgia State University, Louisiana State University, New York Stock Exchange, University of North Carolina at Chapel Hill, Texas A&M University and at the NYSE Conference on the Future of Global Equity Trading for helpful comments. We are especially grateful to comments and discussions with Paul Bennett, Hank Bessembinder, Ekkehart Boehmer, Robert Hardy (Fleet Specialists), Christian Leuz, Ailsa Roell, Gideon Saar, René Stulz, Glenn Surnamer (VDM Specialists), and Ingrid Werner. Roger Loh provided exceptional research assistance for which we are also grateful.

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I. Introduction

With the enhanced globalization of financial markets, the number of non-U.S. firms choosing to cross-list shares on a U.S. exchange has increased substantially. In 1990, there were only 352 non-U.S. stocks listed on the New York Stock Exchange (NYSE) and Nasdaq, but, by the end of 2002, the number has more than doubled to over 850. If one includes stocks trading over the counter (OTC) and as private placement issues, the number of non-U.S. companies with shares trading in the U.S. now exceeds 2,300. This dramatic increase reflects not only U.S. investors' need for international diversification, but also the desire of foreign companies to access global capital, broaden their shareholder base, and enhance company visibility. Corporations generally view U.S. cross-listings as value-enhancing decisions, but there is disagreement about the sources of the benefit.¹ One of the benefits most-frequently cited in surveys of company managers and investors alike is the increased liquidity in share trading associated with the U.S. listing (Mittoo, 1992; Fanto and Karmel, 1997). Indeed, empirical evidence indicates that a U.S. listing is accompanied by a large 40 to 50 percent increase in the number and value of shares traded in the combined U.S. and home market compared to that in the home-market before the listing (Smith and Sofianos, 1997; Foerster and Karolyi, 1998).

However, not all companies experience the benefits of increased liquidity. In fact, a remarkable feature of trading activity in cross-listed stocks on U.S. exchanges is the great variability in the U.S. fraction of global trading. For some stocks, U.S. trading typically represents less than 5 percent of global trading in any given month, while, in other stocks, U.S. trading comprises well over 90 percent of global trading. Moreover, it is not simply country-level factors, like regulatory restrictions or the extent of overlapping trading hours, that dictate these outcomes, as there is significant cross-sectional diversity in the U.S. fraction of trading even among stocks from the same country. Consider, as an example, the different experiences for two firms from the same home market over the same period (Figure 1). Monthly trading volume (in number of shares traded) on the NYSE for Tomkins, a U.K. engineering company, has rarely risen over 2 percent of its combined global volume (NYSE and the London Stock Exchange) since it listed on the NYSE in 1988, while GlaxoSmithKline, a U.K. pharmaceutical company, has maintained a U.S. fraction of trading over 30 percent, at least for all but the last years of the decade.

Understanding why such different multi-market trading environments arise is of paramount importance for managers of all cross-listed companies, but especially those with little U.S.-based trading activity, as it potentially reflects on the long-term viability of the listing and its potential as a vehicle for raising capital, for broadening the shareholder base and for enhancing the company's visibility and profile. Global investors, particularly arbitrageurs that actively trade in both overseas ordinaries and their equivalent cross-listed shares in the U.S., also care about how the trading activity is apportioned across the two markets as it affects the feasibility of their strategies.² Moreover, understanding the factors that affect the distribution of global trading volume is also important to stock exchanges, which compete with each other for new listings and for order flow among existing listings.

In this paper, we develop a new model of multi-market trading to explain the variation in the U.S. share of global trading volume across the sample of non-U.S. stocks cross-listed on U.S. exchanges. The model derives an equilibrium which predicts that, under fairly general conditions,

the distribution of trading volume across exchanges competing for order flow is related to the correlation of the cross-listed asset returns with the returns of other assets traded in the respective markets. The model is based on a standard Kyle (1985) framework with two stock exchanges and three assets: one asset traded exclusively in the first market, a second asset traded exclusively in the second market and the cross-listed asset, which is traded on both exchanges. The two exchanges are segmented in that the risk-neutral market makers observe the order flow of assets only on their own exchange. The informed traders, who observe private information about the different assets, and discretionary liquidity traders are able to trade on either market and even across markets. Because the asset returns on each exchange are correlated, competitive market makers, when pricing an asset, can infer information not only from the asset's own order flow, but also from the order flow of other assets traded on the exchange. Indeed, in equilibrium, the more correlated the returns of the two assets, the more relevant the order flows to one asset are for the pricing of the other asset, and the less sensitive the price of any one asset to its own order flow. This outcome guides the liquidity traders in choosing where to trade the cross-listed asset: the higher the correlation in returns of the cross-listed asset with the domestic asset, the more informative the domestic asset's order flow, which leads both liquidity and informed traders to submit a larger proportion of their orders in the cross-listed asset to that exchange. That is, proportionally more volume takes place on the market in which the cross-listed asset has greater correlation with the other assets traded on that market.

Our new model of multi-market trading represents an important departure from the best-known models to date, including Pagano (1989), Chowdhry and Nanda (CN, 1991) and Domowitz, Glen and Madhavan (DGM, 1998) in that neither exchange design nor assumptions of differential trading costs play a central role in determining the distribution of trading volume across exchanges.³ For example, Pagano's two-period model with risk-averse investors abstracts from asymmetric information considerations and focuses on the role of traders' expectations of other traders' actions. His key result is a "knife-edge" Nash-type of equilibrium in which both markets can survive, but only if a number of special assumptions about exchange design, such as equal transactions costs and equal numbers of traders in each market, hold. CN does allow for asymmetric information, like we do, by extending the framework of Kyle (1985) and Admati and Pfleiderer (1988) to allow simultaneous trading in multiple markets. Their informed investors trade strategically to maximize profits from their private information by locating trades across markets according to which markets are "thick" with liquidity traders. Liquidity naturally clusters in a particular market, which CN define as their "winner takes most" equilibrium. We differ from CN because we model the trading decisions of both informed and discretionary liquidity traders and because the exchanges in our model provide different liquidity in the cross-listed asset by means of the joint distribution of the asset returns traded on each exchange and not by way of assumptions about the number of "small" liquidity traders that are confined to each market.

Our model is also different from that of DGM who extend the model of Glosten and Milgrom (1985) to allow investors to trade in the home-market or the new cross-listed market at differential costs of execution due to the bid-ask spread and the different costs of information acquisition in the two markets. Their model relies on incremental information acquisition costs to ensure that local investors will find it cheaper to trade locally, unless there is perfect transparency in quotes between the two markets, in which case cross-listing will lower volatility due to lower spreads from greater volume overall and more intense competition for order flow from both exchanges can arise. They conclude that CN's "winner takes most" equilibrium is complicated by

the degree of transparency between the two markets. Our model does not rely on assumptions about information acquisition costs to yield the important differences in trading costs. Rather, the choice of where to trade stems from the liquidity that arises endogenously from the extent of the correlation of the cross-listed asset's returns with the returns of other assets traded on a particular exchange.

We proceed to test the key prediction of our model and find strong empirical support. We examine weekly trading stock price and volume data from the home market and the NYSE/Nasdaq for 251 companies from 24 emerging and developed countries around the world. We compute the average U.S. fraction of global trading for each stock based on available data from January 1995 to December 2004. Using U.S. dollar-denominated home-market returns on the stock, we construct a “U.S. information factor,” which is our proxy of the correlation of the cross-listed stock’s returns with information signals about the values of other assets traded in the home and U.S. market. The ratio is computed from multi-index market model regressions of the individual stock's returns on U.S.-dollar-denominated returns of the home market index and a U.S. market index (S&P 500). Specifically, we measure the factor as the incremental explanatory power of the U.S. market in terms of the difference in R-Squared of a two-index model including the U.S. index relative to the R-Squared of a single-index model with just the home market index, adjusted for degrees of freedom. Even after controlling for potential endogeneity effects as well as a host of other firm-specific (e.g. market capitalization, U.S institutional ownership, foreign ownership restrictions, and home market analyst coverage), issue-specific (e.g. NYSE versus Nasdaq) as well as regional and country factors (e.g. time-zone effects), we find that the U.S. fraction of global trading is strongly, positively related to the U.S. information factor, which is consistent with our theory.

Our paper makes an important contribution to the existing empirical work on multi-market trading. To date, the most comprehensive empirical study of the distribution of global trading in internationally cross-listed stocks is Pulatkonak and Sofianos (1999).⁴ Their study examines 1996 trading volume data for 254 NYSE-listed non-U.S. stocks. They estimate an econometric model explaining the variation in the U.S. share of global trading volume drawing from country-specific, company-specific and issue-specific factors. The most important variable in their model is the time-zone factor; 40 percent of the variation of the U.S. market share can be explained by the hours of overlap in trading between the NYSE and the home market for the stock. Surprisingly, other variables, like differential trading costs, an industry dummy, market capitalization, whether or not the issue was associated with a capital raising and what kind of cross-listing is employed (direct ordinary listing, New York Registered Share, American Depositary Receipt (ADR), Global Registered Share), explain relatively little of the cross-sectional variation. Our theoretical model predicts a new “information factor” variable for consideration in the model and we find strong empirical support for this variable, even after controlling for time-zone effects and other variables.⁵

The remainder of this paper is organized as follows. Section 2 develops our multi-market model of trading. We outline the predictions of the model, as well as a series of testable alternative hypotheses, for our empirical analysis which follows in Section 3. We describe the sample of firms, data sources, variable construction, econometric model and main results. Section 4 concludes the paper.

II. Analytical Framework and Testable Hypotheses

A. The Model

We consider a world with two stock exchanges (denoted by subscripts 1 and 2). Two assets are listed on each exchange. Exchanges are organized as a standard Kyle (1985) market, where competitive risk-neutral market makers make the market for the assets listed on their exchange. To have a meaningful separation between exchanges, we introduce the following segmentation. We assume that before setting the prices, market makers observe the net order flow of all the assets traded on their exchange. They do not, however, observe the orders submitted to the other exchange. After each round of trading, a public announcement is made after which the risk-neutral market makers agree that the prices of the assets traded on the first and second exchanges have changed by the innovations, $\nu_1, \nu_2 \in R^2$, respectively. Specifically,

$$\begin{aligned}\nu_1 &= F_1 s + \varepsilon_1 \\ \nu_2 &= F_2 s + \varepsilon_2\end{aligned}$$

where,

$$F_1 = \begin{pmatrix} 1 & 0 \\ a & b \end{pmatrix} \text{ and } F_2 = \begin{pmatrix} 0 & 1 \\ a & b \end{pmatrix}. \quad (1)$$

s, ε_1 and ε_2 are zero mean normally distributed random variables that take values in R^2 . Furthermore, s is independent from ε_1 and ε_2 , and the covariance matrix of s , denoted by P , is diagonal,

$$P = \begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix}. \quad (2)$$

We do not impose a restriction on the covariance matrix of the ε s, nor any on the correlation between ε_1 and ε_2 . In particular, we can assume the second element of ε_1 and ε_2 are identical, so the innovations in the second asset traded on each exchange are identical. We hereafter refer to the second asset on each exchange as the cross-listed asset. Similarly, we refer to the first asset on each exchange as the local asset.

The innovation in the price of the local asset traded on the first exchange depends on s_1 , but not on s_2 ; while the innovation in the price of the local asset traded on the second exchange depends on s_2 but not s_1 . The parameters, a, b , measure the exposure of the cross-listed asset to s_1 and s_2 , respectively. Without loss of generality, we assume the value of the assets prior to the innovation is zero and that interest rates are zero.

There are two strategic risk-neutral informed traders. One of them observes s_1 , while the other observes s_2 . The informed traders may submit orders to both exchanges and for all assets. Let $x_i^1, x_i^2 \in R^2$ ($i=1, 2$) be the market order the i -th informed trader submits to the first and second exchange, respectively. Let $x_1 = x_1^1 + x_1^2$ and $x_2 = x_2^1 + x_2^2$ be the aggregate informed orders submitted to the first and second exchange, respectively.

Next, we consider the uninformed liquidity traders. We take the liquidity demand for each asset as given, and assume the liquidity demand for both the local asset and the cross-listed asset are uncorrelated standard normal variables. However, to discuss volume patterns of the cross-listed asset, we have to allow the liquidity traders who trade the cross-listed asset to choose to which exchange they prefer to submit their order, or even to allow them to split their order between both exchanges. As in Admati and Pfleiderer (1988), we assume that there are n risk-neutral discretionary liquidity traders, each of whom has to trade a certain amount of the cross-listed stock. Let w_i be the amount the i -th discretionary trader has to trade. The market views w_i as a zero mean normal random variable. Furthermore, $\text{cov}(w_i, w_j)$ equals zero for $i \neq j$. Thus,

$$1 = \text{var}\left(\sum_{i=1}^n w_i\right) = \sum_{i=1}^n \text{var}(w_i) \quad (3)$$

We let $\alpha(w_i)$ be the fraction of the demand the i -th discretionary trader submits to the first exchange. When $\alpha_i = 1$ (0), then the i -th trader submits his entire order to the first (second) exchange. Let R_1 and R_2 be the covariance matrix of liquidity demand on the first and second exchange, respectively. We have,

$$R_1 = \begin{pmatrix} 1 & 0 \\ 0 & \sum_{i=1}^n \text{var}(\alpha_i(w_i)w_i) \end{pmatrix} \text{ and } R_2 = \begin{pmatrix} 1 & 0 \\ 0 & \sum_{i=1}^n \text{var}((1-\alpha_i(w_i))w_i) \end{pmatrix}.$$

We denote by $y_1 \in R^2$ and $y_2 \in R^2$, the aggregate order flow (i.e. the total orders submitted by both informed traders and liquidity traders) submitted to the first and second exchange, respectively. Anonymity of trade and segmentation of markets imply that market makers in the first exchange can only observe y_1 while market makers in the second exchange can only observe y_2 . Market makers in each exchange set prices $p_1 \in R^2$ and $p_2 \in R^2$ to clear the markets.

The expected profit of the first and second informed traders, conditional on their information, are (superscript t denotes the transpose operation)

$$E[(v_1 - p_1)^t x_1^1 | s_1] + E[(v_2 - p_2)^t x_1^2 | s_1] \quad (4)$$

$$E[(v_1 - p_1)^t x_2^1 | s_2] + E[(v_2 - p_2)^t x_2^2 | s_2], \quad (5)$$

respectively. The only information a discretionary liquidity trader possesses is the knowledge of his own liquidity shock. The expected profit of the i -th discretionary trader who trades the cross-listed asset is,⁶

$$E\left[(v_1 - p_1) \begin{pmatrix} 0 \\ \alpha_i w_i \end{pmatrix} \middle| w_i\right] + E\left[(v_2 - p_2) \begin{pmatrix} 0 \\ (1-\alpha_i)w_i \end{pmatrix} \middle| w_i\right]. \quad (6)$$

An *equilibrium* is defined as price rules $p_1, p_2: R^2 \rightarrow R^2$, strategies for the informed traders $x_1^i, x_2^i \in R^2, i = 1, 2$, and an order splitting decision for the discretionary liquidity traders $\{\alpha_i w_i\}_{i=1}^n$ such that,

- The price rules satisfy the condition

$$p_1(y_1) = E[v_1 | y_1] \text{ and } p_2(y_2) = E[v_2 | y_2]. \quad (7)$$

- x_1^i and x_2^i maximize (4) and (5), respectively, for each realization of s_i .
- $\alpha_i(w_i)$ maximizes (6) for each realization of w_i .

A *linear equilibrium* is an equilibrium in which (i) there exist two 2×2 matrices, Λ_1 and Λ_2 , such that,

$$p_1(y_1) = \Lambda_1 y_1 \text{ and } p_2(y_2) = \Lambda_2 y_2,$$

(ii) the informed traders' strategies are linear in the signals; i.e. there exist two 2×2 matrices, β_1 and β_2 , such that,

$$x_1^1 + x_1^2 = \beta_1 s \text{ and } x_2^1 + x_2^2 = \beta_2 s,$$

and (iii) the order splitting decisions of all discretionary liquidity traders are identical. In particular, they are independent of their liquidity shocks; i.e. $\alpha_i = \alpha$ for some constant α . In the following, we focus on the properties of a linear equilibrium.

Let the scalar λ_1 be the second row, second column entry of the matrix Λ_1 . Then, λ_1 is the price impact of a market order for the cross-listed asset on the first exchange. Indeed, a change in the demand for the cross-listed asset on the first exchange by the amount Δ results in a price change of the cross-listed asset on the first exchange by $\lambda_1 \Delta$. Similarly, λ_2 , the second row second column entry of the matrix Λ_2 , is the price impact of a market order for the cross-listed asset on the second exchange.

Theorem 1. *A linear equilibrium exists. Let the matrices F_1 , F_2 and P be given by (1) and (2). Let the 2×2 matrices R_1 , R_2 , Λ_1 , Λ_2 , β_1 , β_2 , and the scalar, α , be a solution to the system of equations,*

$$\begin{aligned} R_1 &= \begin{pmatrix} 1 & 0 \\ 0 & \alpha^2 \end{pmatrix} \\ \beta_1 &= (\Lambda_1 + \Lambda_1')^{-1} F_1 \\ \Lambda_1 &= F_1 P \beta_1' (R_1 + \beta_1 P \beta_1')^{-1} \\ R_2 &= \begin{pmatrix} 1 & 0 \\ 0 & (1-\alpha)^2 \end{pmatrix} \\ \beta_2 &= (\Lambda_2 + \Lambda_2')^{-1} F_2 \\ \Lambda_2 &= F_2 P \beta_2' (R_2 + \beta_2 P \beta_2')^{-1} \\ \alpha &= \frac{\lambda_2}{\lambda_1 + \lambda_2}, \end{aligned} \quad (8)$$

subject to the second order conditions that $-(\Lambda_1^t + \Lambda_1)$ and $-(\Lambda_2^t + \Lambda_2)$ are negative semidefinite matrices. Then, the matrices $R_1, R_2, \Lambda_1, \Lambda_2, \beta_1, \beta_2$, and the constant, α , form a linear equilibrium.

The proof of Theorem 1 is given in the Appendix. Notice that the second order conditions imply that $\alpha \in [0, 1]$. To solve the system, we use the elimination method. For an arbitrary positive α , we solve the first three matrix equations in (8) subject to the second order condition. To emphasize that the solution we get depends on the arbitrary choice of α , we write the solution as a function of α . In particular, we get

$$\lambda_1(\alpha) = \frac{1}{2\alpha} \frac{\alpha(a^2\sigma_1^2 + b^2\sigma_2^2) + |b|\sigma_1\sigma_2}{\sqrt{(\sigma_2 + \alpha|b|\sigma_2)^2 + \alpha^2 a^2 \sigma_1^2}} \quad (9)$$

and,

$$\lambda_2(\alpha) = \frac{1}{2(1-\alpha)} \frac{(1-\alpha)(a^2\sigma_1^2 + b^2\sigma_2^2) + |a|\sigma_1\sigma_2}{\sqrt{(\sigma_2 + (1-\alpha)|a|\sigma_1)^2 + (1-\alpha)^2 a^2 \sigma_2^2}}. \quad (10)$$

To find the equilibrium α , we solve the last equation in (8) for α using (9) and (10). We get four possible solutions for α :

$$\left\{ \frac{\sigma_1(|a|\sigma_1 + \sigma_2)}{|a|\sigma_1^2 - |b|\sigma_2^2}, 0, 1, \frac{\sigma_1(|a|^3\sigma_1^3 + a^2\sigma_1^2\sigma_2 + b^2\sigma_2^2|a|\sigma_1 - \sigma_2^3b^2)}{a^2\sigma_1^2|b|\sigma_2^2 - |a|^3\sigma_1^4 + \sigma_2^4|b|^3 + b^2\sigma_2^2|a|\sigma_1^2} \right\}. \quad (11)$$

The first solution does not satisfy the condition $\alpha \in [0, 1]$.⁷ The solutions $\alpha = 0$ and $\alpha = 1$ are the trivial equilibria. If a discretionary liquidity trader conjectures all other liquidity traders trade at the first (second) exchange, he too, regardless of what the values of a and b are, submits his orders to the first (second) exchange. The fourth possible solution in (11) is the interesting one, because this solution depends on the values of a and b . The fourth solution, however, is valid in a certain region. That said, there is a family of equilibria with properties that change continuously with the parameters a and b . We use that family of equilibria to present our comparative statics related to trading volume on the two exchanges. We find it simpler to fix b and let a vary. Because of the symmetry of the model, analogous results hold when we fix a and let b vary. The following corollary formalizes this result.

Corollary 1. *Let b, σ_1 and σ_2 be given. Then, for each a , there is a linear equilibrium, $\Lambda_1(a), \Lambda_2(a), \beta_1(a), \beta_2(a), \alpha(a)$, such that the element of the matrixes, $\Lambda_1(a), \Lambda_2(a), \beta_1(a), \beta_2(a)$, and $\alpha(a)$, are continuous in a . Moreover, $\alpha(a)$, the portion of trade submitted to the first exchange, increases with $|a|$. Furthermore, if $b^2\sigma_2^2 < \sigma_1^2(a^2\sigma_1^2 < \sigma_2^2)$ and if,*

$$a^2 \geq \frac{b^2\sigma_2^2}{\sigma_1^2} \frac{\sigma_1 + |b|\sigma_2}{\sigma_1 - |b|\sigma_2} \left(b^2 \geq \frac{a^2\sigma_1^2}{\sigma_2^2} \frac{\sigma_2 + |a|\sigma_1}{\sigma_2 - |a|\sigma_1} \right), \quad (12)$$

then all trade of the cross-listed asset takes place on the first (second) exchange.

The proof of the corollary is straightforward. If $b^2\sigma_2^2 < \sigma_1^2$ and $a^2\sigma_1^2 < \sigma_2^2$, then there is a linear equilibrium with,

$$\alpha = \frac{\sigma_1(|a|^3\sigma_1^3 + a^2\sigma_1^2\sigma_2 + b^2\sigma_2^2|a|\sigma_1 - \sigma_2^3b^2)}{a^2\sigma_1^2|b|\sigma_2^2 - |a|^3\sigma_1^4 + \sigma_2^4|b|^3 + b^2\sigma_2^2|a|\sigma_1^2}. \quad (13)$$

Differentiation with respect to $|a|$ shows α is increasing in $|a|$. However, if $b^2\sigma_2^2 \geq \sigma_1^2$ and $a^2\sigma_1^2 \geq \sigma_2^2$, then (13) may be smaller than zero or greater than one. In the former case, we use the trivial equilibria in which $\alpha = 0$ and, in the latter, we use the trivial equilibria in which $\alpha = 1$, so that the family of equilibria has properties that vary continuously in a .

It is worth contrasting the equilibrium solution from our model with two other well known models of multi-market trading: Pagano (1989) and Chowdhry and Nanda (1991). Pagano shows that an equilibrium exists in his model in which both markets can survive, but only if a number of restrictive assumptions are satisfied, such as equal transactions costs and an equal number of traders in each market. If these restrictions are not satisfied then only a single market remains open in equilibrium. In Chowdhry and Nanda's equilibrium, informed traders will allocate more of their trades to the market that is "thick" with liquidity traders. However, the extent to which liquidity trade clusters in a given market is driven by exogenous assumptions about the number of "small" liquidity traders in each market. In contrast, we make no assumption regarding the distribution of "small" liquidity traders and endogenize the choice of where to trade for both the informed and the "discretionary" liquidity traders. Two of the possible equilibria in our model have only a single market survive. However, in contrast to Pagano, these single market equilibria are not stable in the following sense: if we were to introduce in our model traders who are confined to trade in one market (small liquidity traders), then this market would attract also informed and discretionary trading; i.e., the trivial equilibria with concentration would disappear. Thus, the natural equilibrium outcome in our model is to have trade occurring in both markets. Moreover, the fact that the properties of the family of equilibria that we derive change continuously as a function of the parameters a and b allow us to derive cross-sectional predictions about differences in trading volume across stocks while holding other parameters constant.

Figure 2 illustrates the results presented in the corollary. The figure shows how the equilibrium portion of trading volume in the first exchange varies with the sensitivity, a , of the cross-listed asset's value to s_1 . The graph displays three representative families of equilibria for three different ratios of the variance of s_1 relative to the variance of s_2 , which is normalized to one. The figure demonstrates that for a small enough, all trade takes place on the second exchange (i.e. $\alpha = 0$) while for a large enough all trade occurs on the first exchange. The intuition for this result, which forms the basis for our empirical analysis, is as follows. When pricing an asset, market makers can infer information not only from the asset's own order flow, but also from the order flow of other assets traded on the same exchange. In equilibrium, the more correlated the returns of the two assets, the more relevant the order flows to one asset are for the pricing of the other asset, and the less sensitive the price of any one asset to its own order flow. This outcome increases the liquidity of the cross-listed asset, which guides the liquidity traders in choosing where to trade. That is, proportionally more volume takes place on the market in which the cross-listed asset has greater

correlation with the other assets traded on that market. In all but extreme cases both markets remain open, however, because the discretionary liquidity traders split their orders across the two exchanges in order to minimize their average trading costs.⁸

B. Model Extension

One important assumption in our model is that the competitive risk-neutral market-makers, before setting prices, observe the net order flow of the assets traded on their own exchange, but do not observe the order flow in the other exchange. This matters because local market makers are thus conferred a comparative advantage in understanding local innovations by virtue of their exclusive view of the local asset's order flow. How reasonable this assumption about unobservability of order flow across markets is in reality, however, is unclear.⁹ There may, after all, be competitive multi-market-trading scenarios in which the markets are so close (say, geographically or in the same time zone) that this complete unobservability restriction is false.

In order to investigate the robustness of our model's predictions, we developed an extension to the model that allows for complete observability of the order flow in the other market for the market makers while maintaining some information asymmetry between the two groups of market makers. To keep the model tractable, we make two simplifying assumptions: (1) there exists only the cross-listed asset, and (2) liquidity traders can choose how much to trade, but are confined to do so only in their own market (e.g., no order-splitting). Now, market makers in the two competing exchanges can observe demand for the cross-listed asset in both exchanges, but the special role previously played by the purely-domestic assets in understanding the local innovation is replaced with an exogenous signal. The resulting equilibrium defines price rules that are linear in the exogenous signal that the market makers observe and in the order flows to *both* exchanges. More importantly, so long as the exogenous signals observed by the market makers are not identical, the key comparative statics obtain. That is, the differential price impact of market orders for the cross-listed asset on the two exchanges is directly related to the relative magnitude of the exposures of the asset's price innovations to the signals in the two markets. The higher is the exposure to the signal on a given exchange, the greater the liquidity that exchange provides and the more aggressively discretionary liquidity traders trade in that exchange.

The model extension makes clear that it is not the unobservability of order flow per se that drives our predictions about volume. Rather, the necessary condition for our result is that the local market maker in each market has some comparative advantage relative to his counterpart in the other market in understanding the local innovation to which the cross-listed stock is partially exposed. Of course, there may be more complex generalizations which we have not considered for which these inferences may be less clear. The details of the extended model are furnished in an appendix (which is available from the authors upon request).

C. Testable Alternative Hypotheses

There may be several possible reasons why overseas investors may wish to trade shares of cross-listed stocks in a particular market that are not related to informational motives at all. Additionally, there may be informational motives for trading that stem from informational advantages favoring one investor over another that are unrelated to our central hypothesis about

market-makers' inferring news from the order flows of other stocks trading on a given market. Within the framework of our model, these additional factors can be thought of as market frictions that keep traders captive in a specific trading venue. In this subsection, we propose a number of alternative testable hypotheses which we exploit in the empirical analysis to render additional power to the tests.

Among non-information-related factors that might influence the extent of U.S. share of trading volume of cross-listed stocks, differences in trading costs (commissions, transactions taxes) or regulatory restrictions (foreign ownership limits, currency convertibility constraints) are among the most important. Empirical evidence indicates that U.S. markets hold an absolute advantage over most other markets in terms of transactions costs,¹⁰ and emerging markets clearly are subject to much higher transactions costs and regulatory barriers than developed markets, so it is important to control for these country-level differences in our empirical analysis. Because most of these factors manifest themselves at the country level, they cannot explain cross-sectional differences in the proportion of U.S. trading among stocks from the same country, which is our focus. However, there are also firm-specific barriers in some emerging markets that relate to the maximum number of home-market shares that are allowed to become eligible to trade overseas in cross-listed form. This is the case, for example, in several Korean, Taiwanese and Indian companies trading on major US exchanges with explicit ceilings on the number of shares that can become ADRs.¹¹

Cost considerations associated with the breadth and composition of the ownership base of the firm might also influence the extent of trading in different markets. It might be, for example, that differences in transactions costs matter less for retail than institutional investors, who are more strategic in their trade-execution decisions. Institutional traders are more likely to split their orders across markets to minimize the net price impact of their trades, even if there is a perceived absolute advantage in terms of lower overall transactions costs in the U.S. If this is true, a larger U.S. ownership base will be associated with a higher fraction of overall trading in the U.S., but this effect will be even greater if the U.S. ownership base is dominated by retail investors than more strategically-motivated institutions that actively seek to minimize their overall trading costs. These inferences will reverse, however, if institutions are in fact more likely to be constrained by prudential policies by their plan sponsors or oversight boards that limit them from directly holding stock abroad and that require them to hold only ADRs or other forms of cross-listed shares instead.

Another non-informational factor is related to the diversification opportunities that cross-listed stocks present for overseas investors. Cross-listed stocks with low return correlations with the U.S. market should be good candidates for diversification purposes.¹² This prediction is particularly useful to us as it represents a specific testable alternative to the central hypothesis of our model; that is, cross-listed stocks whose returns are weakly correlated with other U.S. stocks furnish market makers lower quality information about order flow dynamics and are *less* likely to attract U.S. trading volume.

Informational motives that are not necessarily related to the correlation structure of returns are also likely an important factor in determining the global distribution of trading volume for cross-listed stocks. For example, it has been argued that local investors have an informational advantage relative to foreign investors.¹³ The information hierarchy that favors local investors may arise from geographic proximity to the company's main business operations (Coval and Moskowitz, 1999),

language barriers for foreign investors (Grinblatt and Keloharju, 1999; Hau, 2001) or a greater familiarity with a firm's operations, accounting practices or its capital market environment. While such advantages need not affect the location of trading volume, in many cases it will be cheaper and quicker to trade in the home market, especially if the information is short-lived and speed of execution is critical. Based on this argument, we predict that firms with certain attributes will mitigate this informational disadvantage for foreigners. For example, the fact that larger companies are more visible than smaller firms should lead to a positive correlation between market capitalization and foreign trading volume (Merton, 1987; Kang and Stulz, 1997). If a familiarity bias exists among investors (Grinblatt and Keloharju, 1999; Hau, 2001), then cross-listed companies with a larger fraction of foreign sales should be more likely to develop an active foreign market for the trading of their shares. Similarly, greater familiarity may arise from a larger contingent of industry peers trading in one venue relative to another, a factor that some have suggested as a rationale for cross-listings in the first place (Pagano, Roell and Zechner, 2003; Sarkissian and Schill, 2004). If the total market capitalization of peer firms from the same global industry sector as the cross-listed firm is higher in the foreign market than in the firm's home market, we would predict a higher foreign trading volume would arise.¹⁴ Finally, more research published by analysts can increase the public information available to all investors (Lang, Lins and Miller, 2003; Bailey, Karolyi and Salva, 2005), so we predict that the number of analysts following the cross-listed stocks is positively related to foreign trading volume.

In the next section, we describe the empirical tests of our theory. The sample of U.S. cross-listed stocks is first identified; we then outline how our information factor variable is constructed. In addition, we discuss various proxy variables we propose to evaluate the testable alternative hypotheses defined above.

III. Empirical Analysis

A. Data and Sample

In this section we provide some empirical evidence regarding the relevance of the model developed in the earlier part of the paper. The primary prediction of the model, as expressed in Corollary 1, is that when the value of the cross-listed stock is more sensitive to information in the U.S. market relative to information in the home market then the U.S. will have a higher share of the overall trading volume in the stock. To examine this prediction we collect an initial sample of all stocks cross-listed on U.S. exchanges with listing dates prior to January 1, 1999 that also have stock price data available for both the U.S. and the home market from Datastream International. This initial sample consists of 384 cross-listed stocks with daily data on stock price, trading volume, and the market value of equity over the period beginning in January 1991 and ending in December 2004. Cross-listed securities, which trade in the U.S. in the form of ADRs, are often bundled in a ratio different from one-to-one. For example, the ADR for Telefonos de Mexico, a Mexican company, represents 20 underlying Mexican shares, while the ADR for Norsk Hydro, a Norwegian company, represents a single underlying Norwegian share. To compute the U.S. share of trading volume in each stock we require an accurate measure of the bundling ratio between the home market and cross-listed securities. We obtain the most recent bundling ratio for each stock from Citibank's Universal Issuance Guide. Unfortunately, many cross-listed securities alter their bundling ratios over time. To ensure that we obtain an accurate representation of the bundling ratios for the stocks

in the sample we compare the bundling ratios from the Citibank Universal Issuance Guide to the yearly average of the ratio the month end price in the U.S. market to the month end price in the home market (converted to U.S. Dollars). If the price ratio differs from the reported bundling ratio by more than 20% we attempt to reconcile the discrepancy by examining other sources (such as the ratios reported along with the firm names in Datastream). After eliminating stocks for which we are unable to obtain an accurate bundling ratio we are left with a final sample of 251 cross-listed securities representing 24 different countries. By way of comparison, Pulatkonak and Sofianos (1999) employ a sample of 254 stocks cross-listed on the NYSE. Pulatkonak and Sofianos also provide a detailed description of the different types of cross-listed securities.

B. Variable Construction and Econometric Model

To test the prediction of the model we require a measure of the sensitivity of the stock's value to information in the U.S. relative to information in the home market. Eun and Saberwahl (2003) compute a measure of the U.S. information share using an error correction model and intradaily data for a sample of 52 Canadian stocks. While their measure is intuitively appealing it cannot be employed in our setting both because we lack intradaily data and because many of the stocks in our sample are not traded during the same hours in both the U.S. and home markets due to differences in time zones across countries. Instead we take a more macro view of measuring the sensitivity of the stock's value to information in the U.S. market. Our underlying assertion is that stock prices respond primarily to new information, and we focus on the relative informativeness of market movements in the U.S. and the home country. Specifically, for each stock, we perform a variance decomposition of returns converted to U.S. dollars to estimate the contribution of information contained in U.S. market index returns relative to the information content of index returns in the home market. To perform the variance decomposition we first estimate the following two time-series regressions for each stock:

$$\begin{aligned}
 R_{it} &= \alpha_i + \sum_{k=-1}^{+1} \beta_{i,H,t+k} R_{Home,t+k} + \varepsilon_{it} \\
 R_{it} &= \alpha_i + \sum_{k=-1}^{+1} \beta_{i,H,t+k} R_{Home,t+k} + \sum_{k=-1}^{+1} \beta_{i,US,t+k} R_{US,t+k} + \varepsilon_{it}
 \end{aligned}
 \tag{14}$$

where R_{it} is the return (measured in U.S. dollars) for stock i in period t , $R_{Home,t+k}$ is the return denominated in U.S. dollars on the market index in the stock's home country in period $t+k$, and $R_{US,t+k}$ is the dollar denominated return on the U.S. market index in period $t+k$. The lead and lag terms in the regressions are used to account for non-synchronous trading across markets in different time zones. In addition, to deal with the possibility of infrequent trading at the stock level we base our analysis on weekly returns. The first regression in equation (14) is considered the restricted regression and the second regression in equation (14) is considered the unrestricted regression. Assuming n observations for the stock, six regressors in the unrestricted model, and three restrictions, we compute an F-statistic for each stock that measures the explanatory power of the unrestricted model relative to the explanatory power of the restricted model as follows:

$$\frac{(R_{UR}^2 - R_R^2)/3}{(1 - R_{UR}^2)/(n - 6)}
 \tag{15}$$

By construction, this measure captures the incremental contribution of U.S. market movements in explaining variation in the firm's stock price over and above the information about the firm's stock price contained in movements in the firm's home market index. Our theory, therefore, predicts that higher values of this U.S. "information factor" will correspond to higher U.S. shares of overall trading volume. The U.S. information factor is computed for each stock and each sample year using a minimum of 36 months and a maximum of 48 months of past data. This estimation period ensures that we obtain reasonably precise estimates of the U.S. information sensitivity of the stocks.¹⁵ To the extent that the information factor contains measurement error, we expect an attenuation bias toward zero for the coefficient estimate on this variable in our cross-sectional regression analysis, which biases against finding support for our hypothesis.

For each year in the sample, the U.S. share of overall trading volume for each stock is computed as the weekly average across the year of the ratio of the number of shares traded in the U.S. market, adjusted using the bundling ratio of U.S. shares to home market shares, divided by the total trading volume in both the U.S. and the home market. In computing the U.S. share of trading volume, we include only trading volume in the U.S. and the home market. Some of the securities are also cross-listed in London or on other global exchanges, such as Frankfurt. We do not include the trading volume from the other exchanges in our measure of the U.S. share of trading volume.

Our information factor is computed using returns and it is likely that returns and volume are contemporaneously correlated for reasons outside of those predicted by our model. Because of this it is important that our information factor is computed using data from a different period from the period in which we measure trading volume. To accomplish this, we employ a panel approach and lag the U.S. information sensitivity measure one year. Specifically, the measure of the stock's U.S. information sensitivity computed using returns from years 1991-1994 is used to predict the stock's U.S. volume share in 1995 and so on through the end of the sample period. This experimental design insures that the information factor is predetermined at the time that it is included as an independent variable in the regression. Stocks are allowed to enter and exit the panel over time. Our panel contains 1,416 observations for 251 cross-listed stocks covering the years 1995 through 2004.

In addition to the U.S. information factor we also control for several other factors that could affect the U.S. share of overall trading volume. These other factors are related to the testable alternative hypotheses discussed in the previous section. First, there are a number of country level factors that might affect the U.S. share of trading volume at the country level. For example, there are systematic differences in market size and development, trading commissions, and the legal environment across countries. In addition, Pulatkonak and Sofianos (1999) find that a primary factor affecting differences in the U.S. share of trading volume across stocks are time zone effects: stocks from countries with a time zone closer to that in the U.S. exhibit a higher share of U.S. trading volume. In some of our specifications, we control for time zone effects using a set of indicator variables for different time zones classified in three-hour increments relative to New York. For example, Japan and Korea (which are 10 hours behind New York) and Australia (which is 9 hours behind New York) are classified in time zone -3, while Hong Kong and the Philippines, which are both 13 hours ahead of New York are classified in time zone 4. In the specifications using time zone indicators we also include an indicator for emerging markets versus developed markets where we use the emerging market definition supplied by the International Finance Corporation (IFC). We

predict that emerging markets are more likely to have binding regulatory constraints and higher overall trading costs compared to developed markets, thus leading to proportionally more U.S. trading volume for these stocks. In other specifications, we control directly for country level differences using country level fixed effects. The all-encompassing use of country fixed effects allows us to focus on differences across stocks within countries while removing the effect of all factors that are common to all firms within a country.

Our regression specifications also include a variety of firm specific measures that could potentially affect the stock's U.S. share of trading volume. All of the stocks in our sample are listed on the NYSE or Nasdaq/Amex, and we include an indicator equal to one for firms listed on Nasdaq/Amex in order to account for systematic differences in either actual or reported trading volume across listing exchanges. We also control for firm size using the natural logarithm of the stock's average market value of equity converted to U.S. dollars. Firm size might proxy for the familiarity of the firm to U.S. investors. If this is the case, then we expect firm size to be positively related to the U.S. share of trading volume. Another reason to control for firm size is that large firms are likely to make up a substantial proportion of the market capitalization of the market index in the home country. This could induce a spurious positive correlation between the firm's return and the return on the home market index and bias downward the U.S. information factor for the stock. As additional proxies for the visibility of the firm to U.S. investors, we use the percentage of foreign sales reported by the firm, and the difference in the percentage of the global market capitalization of the firm's industry located in the U.S. and the percentage of global industry market capitalization for the firm's industry in the home country. The foreign sales data is drawn annually from the Worldscope database (Item WC08731) based on fiscal-year-end of December 31. The relative industry capitalization variable is from Datastream International and is based on Level 3 industry grouping codes for the home markets (which include ten global sectors). We expect both foreign sales and the U.S. share of the firm's industry to be positively associated with the U.S. share of trading volume. To capture firm-specific constraints on the U.S. share of trading volume due to regulatory restrictions on foreign ownership, we collect the annual investable weights from Standard and Poor's Emerging Market Database which measure, as a fraction of the market capitalization of the firm, that which is free from explicit foreign investment restrictions.

Higher analyst coverage in the home market potentially reduces the costs of information acquisition for foreign investors trading in the local market. We measure analyst coverage using the natural logarithm of one plus the number of analysts that report earnings estimates for the stock in the home country. These data are from the International Summary database from Thomson Financial's Institutional Brokers' Estimate System (I/B/E/S). We follow Lang, Lins and Miller (2003) in defining analyst coverage for a cross-listed share as the number of estimates that comprise the consensus one-year-ahead earnings estimate for that fiscal year. The data are obtained monthly as of the third Thursday of each month, and we use the December values to measure analyst coverage for the following year. We expect higher analyst coverage in the home market to be negatively related to the U.S. share of trading volume; however, this relationship could be complicated if the information generated by the home-market analysts works to overcome, rather than exacerbate, the informational advantage of locals over foreigners.

Finally, we control for the fraction of the firm's shares owned by U.S. institutions. We would ideally like a breakdown of the full ownership base of these cross-listed firms, but the detailed data

are not readily available. Thomson Financial's 13F database provides quarterly data on the percentage of shares held by U.S. institutions based on filings to the Securities and Exchange Commission. We collapse the quarterly data into annual horizons to align with our panel regression analysis. To the extent that institutional ownership is correlated with the overall size of the U.S. investor base and, if the U.S. market offers absolute advantages in trading costs relative to the home market, we expect that the share of U.S. trading volume will be positively correlated with U.S. institutional ownership. This prediction is less clear, however, if the U.S. institutional ownership base dominates the U.S. retail base. If the more strategically-motivated institutions would be more inclined to split their orders across markets to minimize the overall net price impact of their trades, the U.S. share of trading volume will be less positively correlated with U.S. institutional ownership. If these U.S. institutions, however, are bound by prudential policies that preclude them from directly holding stock abroad and that require them to hold the cross-listed shares instead, then the U.S. share of trading volume will be more positively correlated with U.S. institutional ownership.

C. Summary statistics

Table I reports summary statistics for the stocks in our sample for each country within subsamples of developed and emerging markets. There are 201 stocks from the 14 countries in the sample classified as developed markets and 50 stocks from the 10 countries in the sample classified as emerging markets. Cross listed stocks from Canada (78) and the United Kingdom (40) make up a substantial portion of the sample, however, several other countries, including Australia (13), France (14), Japan (19), the Netherlands (14), Chile (12) and Mexico (14) are also well represented. The U.S. share of trading volume for cross-listed firms from emerging markets averages 33%, which is nearly twice the average U.S. share of trading volume of 17% for cross-listed firms from developed markets. There is also substantial variation in the average U.S. share of trading volume across countries, varying from a low of about 2% for Italy and Switzerland to a high of around 60% for Chile and Mexico. The average value of the U.S. information factor in emerging markets is 2.02, slightly higher than the average of 1.83 for cross-listed firms in developed markets. This suggests that, on average, movements in the U.S. market provide more incremental price-relevant information for cross-listed stocks from emerging markets relative to those from developed markets.

The average market value of equity for stocks from developed markets is \$8.43 billion compared to \$7.79 billion for the average emerging market stock, although these values are highly skewed and vary widely across countries. In terms of the U.S. venue of listing, 33% of cross listed firms in developed markets are listed on Nasdaq compared to only 22% of cross-listed firms in emerging markets. On average, approximately 20 analysts follow firms in the home country in developed markets compared to an average of about 14 analysts in emerging markets. The number of home country analysts varies greatly across countries, however. The percentage of shares held by U.S. institutions averages 8.88% in developed markets and 6.74% in emerging markets. China, Hong Kong, Taiwan and Italy exhibit the lowest levels of U.S. institutional ownership, while Canada, Finland, and Israel exhibit high levels of ownership by U.S. institutions. The investable weight is 100 percent for all developed market firms, but averages only 79 percent for emerging market firms (interestingly, Korea is the country with the lowest fraction of accessibility at 33 percent over this period). The difference in the percentage of the global market capitalization of the firm's industry located in the U.S. and that in the home market (U.S. Industry Relative) is about 40% on average across both developed and emerging markets. The average percentage of foreign sales reported by firms is nearly 59% in developed markets compared to only 22% for firms in

emerging markets. Finally, we also note that several of our variables are not uniformly available for all of the observations in our panel. Investable weights (1,312 observations) and U.S. institutional ownership (1,282 observations) have the broadest coverage, and the percentage of foreign sales the least (822 observations). We report all of our subsequent results using the largest number of observations possible.

Table II reports the correlation matrix for the variables. Because our interest is primarily on whether the model can explain differences in the share of U.S. trading volume across firms within countries the correlations are reported after subtracting the country mean from each variable. Consistent with the prediction of our model, the U.S. information factor and the U.S. share of trading volume are positively correlated. The signs of the correlations on the other variables are also generally consistent with intuition. Larger firms have a lower share of U.S. trading volume. The U.S. share of trading volume is lower when more analysts follow the firm in the home country and is higher when U.S. institutions hold a larger fraction of the firms' shares and when the firms have higher investable weights (fewer firm-level foreign ownership constraints). The U.S. share of trading volume is also higher for firms with more foreign sales, when the firm's industry is more overrepresented (by market capitalization) in the U.S., and when the investable weight is higher.

D. Multivariate Regression Analysis

To further investigate the factors that affect the U.S. share of trading volume, Table III reports results of a multivariate regression analysis. The dependent variable in the regressions is the logistic transformation of the U.S. share of trading volume. We employ the logistic transformation to account for the fact that the U.S. volume share is bounded between zero and one. All of the specifications include the U.S. information factor from equation (15), firm size, and the indicator variable for cross-listed firms listed on Nasdaq/Amex. In some specifications we also include various combinations of the other control variables. To control for country level differences all of the regressions include either the indicators for time zone and emerging markets or country fixed effects. The table reports White (1980) heteroscedasticity-consistent t-statistics adjusted for clustering at the firm level. All of the independent variables are lagged one year.

The results reported in Table III provide strong support for the prediction of the model. In model (1), which employs the broadest possible sample and controls for country effects using the time zone and emerging market indicators, the coefficient on the U.S. information factor is 0.144 (t-statistic = 4.15), indicating that firms with a higher value of the U.S. information factor have higher U.S. shares of trading volume. The coefficient estimates on the control variables also appear reasonable. Larger firms exhibit a lower share of trading volume in the U.S., and firms from emerging markets have a higher U.S. share of trading volume, all else equal. The Nasdaq indicator is not statistically different from zero. Model (2) adds additional control variables for home analyst coverage, U.S. institutional ownership and the relative share of the firm's industry located in the U.S. Model (3) adds the investable weight and model (4) adds foreign sales to the specification as well. Because of missing values, the number of observations drops from 1,416 in model (1) to 958 in model (2), 888 in model (3) and 720 in model (4). In all four specifications, the coefficient on the U.S. information factor remains positive and statistically significant at the 10 percent level or better. Models (5) through (8) repeat the regressions in Models (1) through (4) but drop the time zone and emerging market indicators in favor of country fixed effects. The results are very similar. The coefficient estimate on the U.S. information factor in model (5) is 0.121 (t-statistic = 3.36)

indicating a slightly smaller effect of U.S. information on the U.S. share of trading volume compared to model (1) after controlling for country level differences. Compared to model (1) the negative effect of firm size on the U.S. volume share is slightly smaller. Models (6) to (8) yield results similar to those in models (2) to (4), with one notable exception: the explanatory power of the investable weight variable is much larger and positive with country dummies and without the emerging markets indicator. This result suggests that there is strong clustering in the investable weight variable among emerging markets.

Overall, the multivariate analysis reported in Table III provides support for the idea presented in our model that cross-listed firms for which price relevant information contained in U.S. market movements is larger will also exhibit a larger share of their trading volume in the U.S. market. In addition, firms with more U.S. institutional ownership are associated with more U.S. trading volume and firms with more home country analyst following exhibit less trading volume in the U.S. Also, the higher is the investable weight for a cross-listed firm, the higher the U.S. share of trading volume. The estimates on the U.S. share of the firm's industry and foreign sales are not significant in any of the specifications. To assess the magnitude of these effects we compute the percentage change in trading volume implied by a movement from the 25th to the 75th percentile in each of the variables of interest based on the regression coefficients in Model (5).¹⁶ The effect of the U.S. information factor on the U.S. share of trading volume is economically meaningful, but is somewhat smaller in magnitude than the effects of analyst coverage and institutional ownership. Moving from the 25th to the 75th percentile of the U.S. information factor implies an increase in the U.S. share of trading volume of over 15%. This compares to a 34% decline in the U.S. share of trading volume for a change of a similar magnitude in home-market analyst coverage and a 26% increase associated with a change of a similar magnitude in institutional ownership.

One additional robustness test we investigated relates to the concern about the restrictive assumption about the unobservability of order flow in the competing market for market makers. We developed an extended model in Section II.B which demonstrates that the key prediction of our model holds when observability in order flow across markets is allowed so long as the local market maker maintains some informational advantage relative to the foreign market maker in understanding the local portion of the innovation in the value of the cross-listed asset. Alternatively, if the observability of order flow eliminates the comparative advantage of the local market maker, then the explanatory power of our information factor for the U.S. fraction of trading volume should be greatly diminished. We performed supplementary regression analysis to test this possibility. As a proxy for the degree of observability among market makers in competing exchanges we created an indicator variable for countries that have a substantial overlap in trading hours with the U.S. The overlap variable is equal to one for cross-listed stocks from Canada, Mexico and Latin America, and is equal to zero for cross-listed stocks from Asia and Europe. Using specifications similar to models (1) and (5) in Table III, but including the overlap variable (in lieu of time zone indicators and when country indicators are not included) and an interaction term between the overlap variable and the U.S. information factor, we found that the overlap variable was positively and significantly related to the U.S. trading volume, indicating that stocks from countries in a similar time zone to the U.S. exhibit a greater share of U.S. trading volume. Nevertheless, the information factor remained significant, positively related to the fraction of trading volume. The interaction variable was positive but not significant, indicating that, if anything, the effect of the information factor on the share of U.S. trading volume is higher in markets with more overlap in trading hours with the U.S.

IV. Conclusions

In considering whether to cross-list their stock on a foreign exchange, such as the NYSE or Nasdaq in the U.S., an issue of concern for managers is the trading activity that the cross-listing will attract. The distribution of trading volume potentially reflects on the long-term viability of the listing and its potential as a vehicle for raising capital, for broadening the shareholder base and for enhancing its visibility and profile. In addition, understanding the factors that affect the distribution of trading volume in cross-listed securities are also important for stock exchanges as they attempt to attract new listings and compete with one another for order flow. The issue is particularly relevant today as a policy debate as many non-U.S. firms are threatening to de-register and de-list from U.S. markets following the passage of the Sarbanes-Oxley Act of 2002 and its increased costs of compliance, auditing independence and penalties for false reporting.¹⁷ Indeed, in part to alleviate these concerns, the Securities and Exchange Commission proposed in December 2005 a new Rule 12h-6 that would ease the burden on non-U.S. firms to arrange termination of registration in the U.S., one important condition of which is based on the fraction of their overall trading volume that takes place in the U.S.¹⁸

In this paper, we develop and test a theoretical model of multi-market trading to explain the differences in the foreign share of trading volume of internationally cross-listed stocks. The model derives an equilibrium which predicts that, under fairly general conditions, the distribution of trading volume across exchanges competing for order flow is related to the correlation of the cross-listed asset returns to returns of other stocks in the respective markets. That is, volume is proportionally higher on the exchange in which the cross-listed asset returns have greater correlation with returns of other assets traded on that market. We test this prediction with monthly stock returns and volume data on 251 non-U.S. stocks cross-listed on major U.S. exchanges. We find strong empirical support for the prediction, even after controlling for possible endogeneity effects and for other firm-specific, issue-specific and country-level factors.

Our work contributes both to the theoretical and empirical literature on multi-market trading and provides an explanation for the great variability that is observed in the distribution of trading activity across exchanges in cross-listed securities. Nevertheless, there are many questions that we leave unanswered. An open question remains about the fundamental forces underlying the information factor that we introduce as an important explanatory variable for the global distribution of trading in cross-listed securities. One possibility is that it arises from the nature of the business activities of the firm related to geography (important U.S.-based operations and assets) or industrial membership (globally competitive industry) that we have not captured fully in our foreign sales and industry-peer proxy variables. A more detailed empirical analysis here would be worthwhile, especially given evidence in Pagano, Roell and Zechner (2002) and Sarkissian and Schill (2004) that trade, colonial ties, common language and culture and similar industrial structure play important roles in the selection of overseas trading venues for international firms. Indeed, there is a significant body of new research that is re-examining the international cross-listing decision of firms in the context of these and other corporate governance-related explanations (Karolyi, 2006). It is still unclear how patterns in the distribution of trading activity across global exchanges may be linked to these explanations. For example, is it possible for a firm to rationalize a decision to cross-list on an overseas exchange in spite of a low information factor and poor prospects for any kind of U.S. market share of trading?

Another open question is whether the dealers and specialists that make markets in non-U.S. stocks on U.S. exchanges perform their function in a way that is likely to influence the proportion of trading activity in the U.S. Indeed, Bacidore and Sofianos (2002) document with proprietary data that the inventory management behavior (positions closer to zero) and participation and stabilization rates (higher) of NYSE specialists in non-U.S. stocks are very different than for U.S. stocks. More recent papers by Bacidore, Battalio, Galpin and Jennings (2005) and Moulton and Wei (2005) show that their market-making activities are significantly different even with a given trading day when the home-market for the cross-listed shares are open and when they are closed. Our effort to now has also made only modest progress in understanding the joint dynamics of information factors and the global distribution of trading volume over time, in general, and around important events like the cross-listings themselves. Indeed, Halling, Pagano, Randl and Zechner (2004) show that the foreign volume shares decline significantly in the first three years following a listing.

Finally, the problem of explaining market shares of trading volume exists in domestic market settings also, and it remains yet to be seen whether the intuition underlying our model has applicability there. There are many competing explanations for why exchanges do or do not compete successfully against third-market dealers or electronic communications networks (ECNs) or why the listed Chicago Board Options Exchange (CBOE) is losing market share to the newer electronically-traded International Securities Exchange (ISE). To this end, it is useful to recognize Baruch and Saar (2004) who have extended a trading model similar to ours to explain why some firms list their shares on one market over another (Nasdaq versus NYSE) and why some firms switch listings.

Appendix

Proof of Theorem 1

If all the liquidity traders submit the same fraction α of their order to the first exchange, then the covariance matrix R_1 and R_2 are given by the first and fourth equation in (8).

Let $i \in \{1, 2\}$. Assume the informed traders' aggregate order is given by $\beta_i s$, and that the liquidity traders use a linear strategy defined by α . The theory of linear filtering implies that (See Bensoussan, 2000, Theorem 1.1.1)

$$E[v_i | y_i] = \lambda_i y_i$$

where

$$\lambda_i = F_i P \beta_i' (R_i + \beta_i P \beta_i')^{-1} ,$$

which are the third and fifth equations in (8).

Given a linear price rule $p_i = \lambda_i y_i$, the j -th ($j \in \{1, 2\}$) informed trader's problem is,

$$\max_{x_1 \in R^2, x_2 \in R^2} E[x_1' (v_1 - \lambda_1 y_1) + x_2' (v_2 - \lambda_2 y_2) | s_j] .$$

Given the linear strategy of the other traders (the other informed trader and discretionary liquidity traders), and segmentation of markets, the problem can be written as

$$\max_{x_1 \in R^2} E[x_1' (E[v_1 | s_j] - \lambda_1 y_1) | s_j] + \max_{x_2 \in R^2} E[x_2' (E[v_2 | s_j] - \lambda_2 y_2) | s_j] .$$

The first order condition implies that

$$\begin{aligned} x_1 &= (\lambda_1 + \lambda_1')^{-1} E[\tilde{v}_1 | s_j] \\ x_2 &= (\lambda_2 + \lambda_2')^{-1} E[\tilde{v}_2 | s_j] . \end{aligned}$$

The first order condition is sufficient if the problem is concave; i.e. if the Hessians of the objective functions are negative semi-definite matrices. The Hessians are $-(\lambda_1' + \lambda_1)$ and $-(\lambda_2' + \lambda_2)$. These are constraints the system (8) has to satisfy.

We also have $E[v_1 | s_1] = s_1$, $E[v_2 | s_1] = a s_1$, $E[v_1 | s_2] = 0$ and $E[v_2 | s_2] = b s_2$. Thus, we can write the aggregate informed demand submitted to the i -th exchange as $\beta_i s$, where β_i is given by

$$\beta_i = (\lambda_1 + \lambda_1')^{-1} F_i ,$$

which explains the second and fourth equations in (8).

To end the proof, we need to derive the last equation in (8). Consider the problem of a discretionary liquidity trader who needs to buy an amount w . Given the linear structure of the price rule and traders' strategies, his problem can be reduced to

$$\max_{\alpha} E(as_1 + bs_2 - \lambda_1 \alpha w) \alpha w + (as_1 + bs_2 - \lambda_2 (1 - \alpha)w)(1 - \alpha)w .$$

Because s_1 and s_2 have zero mean, we can write the problem as

$$\min_{\alpha} (\lambda_1 \alpha^2 + \lambda_2 (1 - \alpha)^2) w^2 .$$

The optimal fraction is independent of the liquidity shock, and it is given by

$$\alpha = \frac{\lambda_2}{\lambda_1 + \lambda_2} ,$$

which is the last equation in (8). This ends the proof.

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Figure I
Multi-Market Trading in Shares of Tomkins (U.K.) and GlaxoSmithKline (U.K.)

Monthly trading volume in thousands of shares traded on home market and in cross-listed shares on U.S. market (left scale) and proportion of combined trading volume taking place on U.S. market.

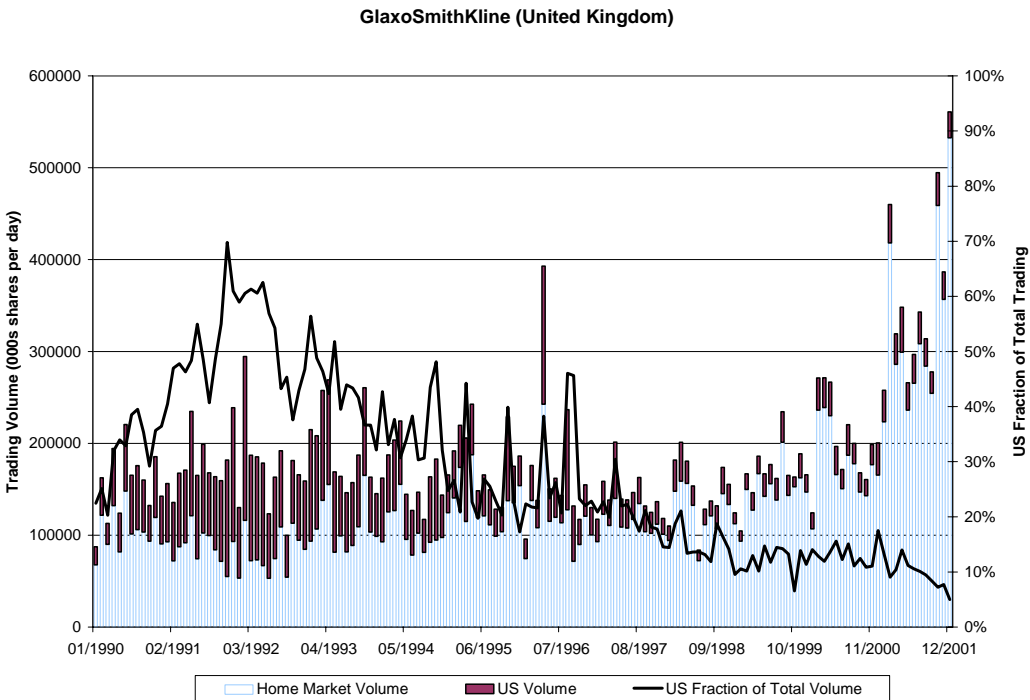
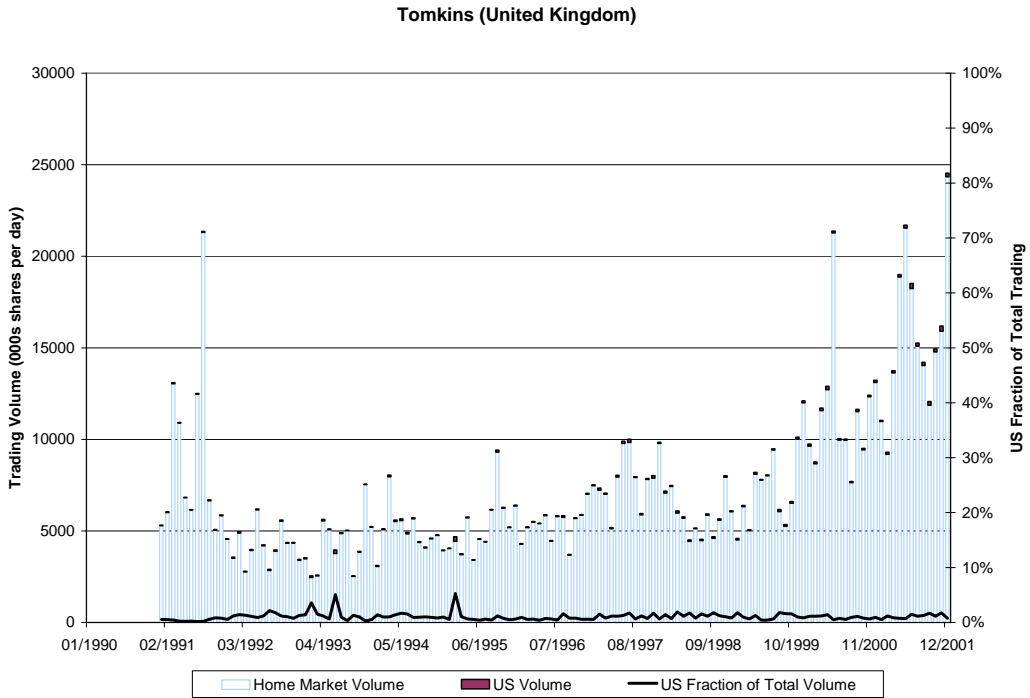


Figure II
Volume Share

Assuming $b = 1$ and $\sigma_2 = 1$, this figure shows how for different values of σ_1 , the portion of liquidity traders' orders submitted to the first exchange varies with the sensitivity of the cross listed asset to s_1 as measured by a . The upper graph shows $\sigma_1 = 2$ and then in decreasing order $\sigma_1 = 1$ and $\sigma_1 = 0.5$.

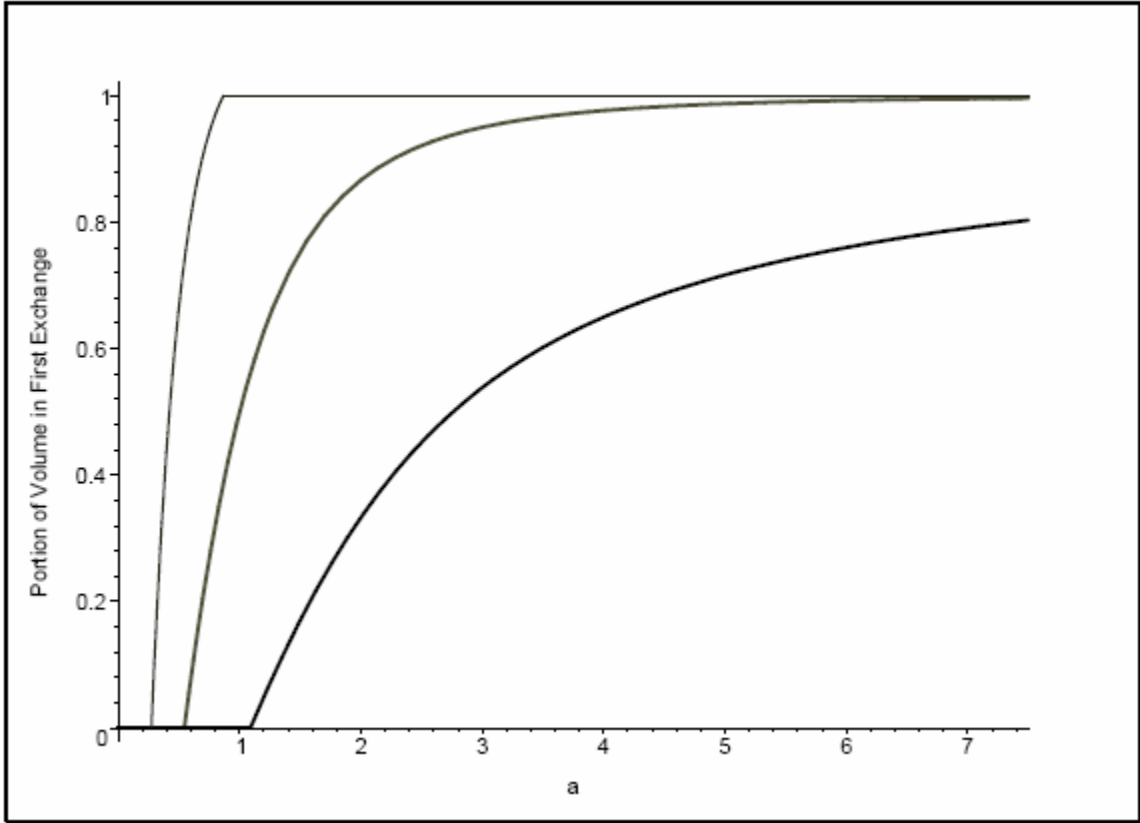


Table I
Sample Summary Statistics

The table reports sample summary statistics by country for our sample of 251 cross-listed firms from 24 countries using a panel of annual statistics from 1995 through 2004. Country means are reported along with overall means for developed and emerging market countries as defined by the IFC. The table reports the number of cross-listed firms in each country, the U.S. share of trading volume, the U.S. Information factor computed using Eqs. (14)-(15), market value of equity (in USD millions), the fraction of firms listed on Nasdaq, the number of analysts following the firm in the home country (Source: I/B/E/S International Summary Database), the U.S. institutional ownership as a fraction of shares outstanding (Source: Thomson Financial's 13F Database), the Investable Weight is the fraction of the market capitalization of the individual firm accessible for foreign investors (Source: Standard & Poor's Emerging Market Database), the U.S. Industry Relative is the difference between the share of global market capitalization of the firm's industry in the U.S. and that in the home country (based on Datastream's Level 3 sector definitions), and the percentage of foreign sales (Source: Worldscope item WC08731).

	Number of Firms	U.S. Volume Share N=1,416	U.S. Information Measure N=1,416	Market value of equity (USD) N=1,416	Nasdaq indicator N=1,416	Home Analyst Coverage N=1,073	U.S. % of Institutional Ownership N=1,282	Investable Weight (%) N=1,312	U.S. Industry Relative (%) N=1,063	Foreign sales (%) N=822
Australia	13	0.15	2.92	8.12	0.32	10.92	1.38	100.0	35.40	33.52
Canada	78	0.42	1.85	6.64	0.47	11.55	23.58	100.0	42.24	67.68
Finland	1	0.40	1.11	11.34	0.00	42.17	30.98	100.0	68.28	78.51
France	14	0.07	1.60	8.56	0.49	18.65	7.07	100.0	45.62	59.56
Hong Kong	1	0.42	3.77	4.99	0.00	8.75	0.60	100.0	26.38	90.86
Italy	6	0.02	0.95	9.00	0.03	29.88	0.50	100.0	26.81	48.99
Japan	19	0.03	2.10	9.54	0.49	15.64	2.48	100.0	23.50	40.48
Netherlands	14	0.24	2.87	9.16	0.34	22.92	11.51	100.0	48.24	64.50
New Zealand	1	0.12	1.15	5.41	1.00	9.00	5.11	100.0	51.90	0.00
Norway	4	0.21	1.12	7.77	0.11	19.89	15.26	100.0	40.79	79.84
Spain	3	0.06	1.08	10.28	0.00	33.38	5.68	100.0	32.45	NA.
Sweden	5	0.13	1.41	9.07	0.97	26.77	7.79	100.0	43.67	85.06
Switzerland	2	0.02	1.84	9.46	0.00	18.57	10.19	100.0	44.37	59.01
UK	40	0.09	1.86	8.69	0.37	12.23	2.22	100.0	36.49	55.65
Developed Mean		0.17	1.83	8.43	0.33	20.02	8.88	100.0	40.44	58.74
Chile	12	0.58	1.20	7.01	0.00	8.91	1.99	79.2	41.46	47.31
China	5	0.13	2.80	7.54	0.00	4.60	0.10	85.6	32.80	11.68
Indonesia	2	0.30	5.32	7.73	0.00	21.36	0.46	NA	32.88	0.00
Israel	5	0.46	1.97	6.83	0.73	2.68	21.14	89.2	54.95	67.43
Korea	1	0.16	1.08	9.34	0.00	19.00	9.59	32.9	41.21	0.00
Mexico	14	0.61	0.97	6.95	0.00	14.52	5.47	90.5	43.05	34.69
Philippines	1	0.49	0.69	7.69	0.00	21.50	18.64	NA	33.71	0.00
Portugal	2	0.03	2.13	9.07	0.00	21.38	5.67	NA	36.35	22.94
South Africa	6	0.35	2.09	6.90	0.90	8.32	3.74	96.5	33.27	30.12
Taiwan	2	0.20	1.94	8.84	0.56	16.57	0.60	NA	67.63	11.80
Emerging Mean		0.33	2.02	7.79	0.22	13.88	6.74	78.9	41.73	22.60

Table II
Correlation matrix of variables

The table reports the correlation matrix for our sample of 251 cross-listed firms from 24 countries. Correlations are measured after subtracting the country mean from each variable, and p-values are reported in parentheses. The variables are defined in Table 1.

	U.S. Volume Share	U.S. Information Factor	Market Value of Equity	Home Analyst Coverage	U.S. Institutional Ownership	Investable Weight	U.S. Industry Relative	Foreign Sales
U.S. Volume Share	1.000							
U.S. Information Factor	0.125 (0.000)	1.000						
Market Value of Equity	-0.147 (0.000)	0.121 (0.000)	1.000					
Home Analyst Coverage	-0.317 (0.000)	0.151 (0.000)	0.630 (0.000)	1.000				
U.S. Institutional Ownership	0.230 (0.000)	0.103 (0.000)	0.257 (0.000)	0.231 (0.000)	1.000			
Investable Weight	0.079 (0.004)	-0.098 (0.000)	-0.062 (0.026)	0.022 (0.498)	0.055 (0.057)	1.000		
U.S. Industry Relative	0.126 (0.000)	0.106 (0.001)	-0.188 (0.000)	-0.183 (0.000)	-0.070 (0.032)	0.080 (0.012)	1.000	
Foreign Sales	0.085 (0.014)	-0.002 (0.958)	0.013 (0.716)	0.037 (0.284)	0.116 (0.002)	0.000 (0.995)	0.064 (0.069)	1.000

Table III
OLS regressions of U.S. Share of trading volume

The sample consists of 251 cross-listed firms from 24 countries for the period 1995 to 2004. The dependent variable in the regressions is the logistic transformation of the U.S. share of trading volume. Independent variables include the U.S. information factor, the natural log of the market value of the firm's equity measured in USD, an indicator equal to one for Nasdaq listings, the log of one plus the number of analysts reporting earnings forecasts for the firm in the home country, the percentage of shares owned by U.S. institutions, the investable weight or firm's equity market capitalization accessible to foreign investors, the difference between the share of the global market capitalization of the firm's industry in the U.S. and the industry share in the home country, and the percentage of foreign sales. Some regression specifications include an indicator equal to one for emerging markets and the time zone of the country and some specifications include indicator variables for each of the 24 countries in the sample. Robust heteroscedasticity consistent t-statistics adjusted for clustering at the firm level are reported in parentheses.

Variable	Dependent Variable: Logistic Transformation U.S. Share of Trading Volume							
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
U.S. Information Factor	0.144 (4.15)	0.102 (2.80)	0.084 (2.15)	0.067 (1.74)	0.121 (3.36)	0.113 (2.88)	0.100 (2.35)	0.086 (2.02)
Firm Size	-0.138 (-1.79)	-0.051 (-0.49)	-0.0582 (-0.54)	-0.006 (-0.06)	-0.116 (-1.60)	0.020 (0.21)	-0.004 (-0.04)	0.033 (0.31)
Nasdaq Indicator	0.269 (0.93)	0.204 (0.67)	0.267 (0.86)	0.373 (1.17)	0.309 (1.08)	0.410 (1.35)	0.420 (1.38)	0.393 (1.18)
Home Analyst Coverage	NA	-0.477 (-1.88)	-0.465 (-1.75)	-0.475 (-1.53)	NA	-0.672 (-2.54)	-0.670 (-2.46)	-0.681 (-2.17)
U.S. Institutional Ownership	NA	0.046 (5.40)	0.045 (5.28)	0.054 (5.86)	NA	0.043 (5.01)	0.044 (5.02)	0.050 (5.48)
U.S. Industry Relative	NA	0.010 (1.37)	0.009 (1.22)	0.010 (1.30)	NA	0.004 (0.57)	0.001 (0.18)	0.004 (0.52)
Investable Weight		NA	0.914 (0.76)	0.369 (0.19)	NA	NA	3.247 (3.57)	4.312 (3.04)
Foreign Sales	NA	NA	NA	0.001 (0.79)	NA	NA	NA	0.001 (0.91)
Emerging Market Indicator	1.353 (3.54)	1.226 (2.79)	1.463 (2.51)	0.982 (1.33)	NA	NA	NA	NA
Time Zone Indicators	Yes	Yes	Yes	Yes	No	No	No	No
Country Indicators	No	No	No	No	Yes	Yes	Yes	Yes
N	1,416	958	888	720	1,416	958	888	720
Adj. R-Squared	0.4197	0.4997	0.4854	0.4890	0.4710	0.5349	0.5313	0.5318

¹ There are many studies of the economic benefits of international cross-listings for issuers including those that focus on the gains from overcoming investment barriers and segmented markets (Alexander, Eun, and Janakiramanan, 1988; Foerster and Karolyi, 1999; Miller, 1999), from expanding the shareholder base (Foerster and Karolyi, 1999), from enhancing visibility among analysts and the media (Baker, Nofsinger and Weaver, 2002; Lang, Lins and Miller, 2003; Bailey, Karolyi and Salva, 2005) and from legal “bonding” to the U.S. legal system to protect minority shareholders (Coffee, 1999; Reese and Weisbach, 2002; Doidge, 2004; Doidge, Karolyi and Stulz, 2004). Karolyi (1998) surveys dozens of earlier studies of the share price and liquidity effects of international listings up to 1998.

² It is difficult to gauge the size of the arbitrage market in internationally cross-listed shares. However, there are a number of vehicles to facilitate the process, including Bank of New York's *DR Converter*, which is a proprietary cost analysis model for ADRs versus home-market ordinaries with web-based access for global investors. Citibank's ADR division has also initiated a new SWIFT centralized messaging system for brokers to reduce settlement risks and delays for ADR issuances and cancellations on behalf of customers. JP Morgan's ADR division has similarly built their *Cross-Book Maximizer* which is the market's first on-line automated marketplace for ADR traders and brokers to execute ADR-ordinary share exchange transactions.

³ Chapter 8 of O'Hara (1997) provides a useful overview of the theoretical literature on liquidity and the relationship across markets.

⁴ A new paper by Halling, Pagano, Randl and Zechner (2004) examines the overseas trading volume for a sample of 111 European firms crosslisted on a variety of overseas exchanges. They test and confirm the explanatory power of our information factor. They also show that the magnitude of overseas trading wanes dramatically in the years following the cross-listing, which leads them to call into question whether providing an active foreign marketplace for shares is a reasonable motivation for cross-listings, at least for European firms.

⁵ Our paper also provides a useful theoretical backdrop for various new studies of price discovery in stocks with multi-market trading (Ding, Harris, McInish, and Lau, 1999; Eun and Sabherwal, 2003; Grammig, Melvin and Schlag, 2005) and for other empirical studies of multi-market trading in dual-listed companies (DLCs, or “Siamese twins”), such as Royal Dutch Shell or Unilever (Rosenthal and Young, 1990; Froot and Dabora, 1999; and, Bedi, Richards and Tennant, 2003) and ADRs (Gagnon and Karolyi, 2004).

⁶ In equilibrium, these profits are negative; i.e. they are payment for immediacy.

⁷ Indeed, for the first solution to be positive, we must have $|a| \sigma_1^2 - |b| \sigma_2^2 > 0$, but this implies that the solution is greater than one.

⁸ Note that splitting orders remains an optimal strategy, even if one market has an absolute advantage in terms of overall liquidity. Menkveld (2004) provides evidence of order-splitting behavior in terms of a positive correlation of signed-volume during the overlapping hours of trading in the Amsterdam and NYSE markets for Dutch cross-listed stocks.

⁹ In fact, the model and empirical results in Domowitz, Glen and Madhavan (1998) demonstrate how less than perfect transparency in quotes between two competing markets can impact liquidity and trading activity in both markets.

¹⁰ See, among others, Table V of Chiyachantana, Jain, Jiang and Wood (2004).

¹¹ These ceilings are usually stipulated in the Securities and Exchange Commission annual filings of Form 20-F in the section entitled “Description of American Depositary Shares” outlined with the conditions under which the ceiling can change over time.

¹² Many explanations abound to explain the “home-bias puzzle” to rationalize why portfolio holdings of investors unduly favor local over foreign stocks in spite of attractive risk diversification opportunities. They parallel the alternative hypotheses we present for the geographic location of trading in cross-listed stocks, including market frictions (Black, 1974; Stulz, 1981), home assets as hedges against home country-specific risks (Adler and Dumas, 1983; Cooper and Kaplanis, 1994) or differences across investors in prior beliefs about expected returns or risks (Pastor, 2000; Glassman and Riddick, 2001).

¹³ This assumption is key to a number of recent explanations and findings of the “home bias” phenomenon in international portfolio holdings (Kang and Stulz, 1997; Grinblatt and Keloharju, 1999; Ahearne, Grier and Warnock, 2004).

¹⁴ This specific alternative hypothesis is a significant challenge for our model's prediction, as the returns correlation of the cross-listed stock with other stocks trading in the new venue should be influenced by the presence of a greater number of industry peers among those other stocks.

¹⁵ Similar results are obtained in our empirical analysis if we use a three year estimation period.

¹⁶ To compute the economic effects, we set the value of all the continuous variables in the regression to their sample mean values. The Nasdaq indicator is set to zero, and the constant term in the regression is set such that the predicted U.S. share of trading volume for this “average” stock is 25% (which is approximately the sample average). The variable

of interest is then varied between the 25th and 75th percentiles (based on within country variation) and the implied U.S. volume share is computed by inverting the logistic transformation.

¹⁷ See February 9, 2004 open letter to then SEC Chairman William Donaldson signed by the Alain Joly, President of the European Association for Listed Companies (EALIC) and several other business associations.

¹⁸ See *Termination of a Foreign Private Issuer's Registration of a Class of Securities Under Section 12(g) and Duty to File Reports Under Section 15(d) of the Securities Exchange Act of 1934* (Dec. 23, 2005) and Condition No. 4 ("Level of U.S. Interest") for equity securities in which the average daily trading volume in the U.S. during a recent 12-month period must not be greater than five percent of the daily trading volume average in the primary trading market and U.S. residents do not hold more than ten percent of the worldwide public float of equity securities.