Speed of convergence to market efficiency for NYSE-listed foreign stocks

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Abstract

This paper contributes to the cross-listing literature by documenting the speed of convergence to market efficiency for foreign stocks listed on the NYSE. We find that on average it takes between 30 and 60 minutes for an ADR to achieve market efficiency. For a comparable U.S. stock listed on the same exchange, it takes only 10 to 15 minutes. The significant difference between foreign and U.S. stocks remains robust when the speed is measured by the number of transactions instead of in calendar time. Among various trading, firm, and country characteristics, factors associated with information asymmetry and investor participation significantly affect the speed to market efficiency for foreign stocks.

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1. Introduction

In addition to listing on a domestic exchange, a firm sometimes chooses to cross-list its shares on a foreign stock exchange. The NYSE is one of the most important listing destinations for foreign firms. At the end of 2005, the number of foreign stocks listed on the NYSE reached 453, a 472% increase from 96 in 1990. During the same period, the number of domestic listings on the NYSE only increased by 34%. Foreign firms account for about 17% of all NYSE-listed companies and their market capitalization represents approximately 37% of the total market capitalization of all NYSE companies at the end of 2005. [1]

The growth motivates a vast literature on cross-listings (see Karolyi 2006 for a survey). Among all the studies, to the best of our knowledge, only two papers study the efficiency of the ADR market. [2] Rosenthal (1983) conducts serial correlation and runs tests on weekly, biweekly, and monthly returns for 54 ADRs over the period of 1974 through 1978. The results are consistent with weak form efficiency. Webster (1998) studies the market efficiency of three ADRs using Dickey-Fuller unit-root test and daily stock prices. The results show that the market for these ADRs is efficient over the daily horizon. Given the finding that ADR market is efficient over the daily horizon, a natural question to ask is how fast the ADR market becomes efficient within a day. The answer to this important question requires intraday analysis using high-frequency data. Rosenthal (1983) and Webster (1998) use daily or lower frequency data and therefore are silent on this issue. In this study, we try to

[1] Data are collected from the NYSE website.

[2] ADR refers to American Depository Receipts. Most foreign firms list their stocks in the U.S. as ADRs. For the basics of ADRs, please refer to www.adr.com, a website maintained by JP Morgan.

contribute to the cross-listing literature by providing evidence on the speed of convergence to market efficiency for ADRs. We use intraday data on a sample of 320 ADRs listed on the NYSE and find that, on average, it takes more than 30, but less than 60, minutes for ADRs to reach efficiency.

Our ADR sample also gives us a unique opportunity to explore several other important issues. On one hand, ADRs share the same trading venue as U.S. domestic stocks listed on the NYSE. The same market mechanism allows a sensible comparison of the speed to market efficiency for ADRs versus domestic stocks. We find that it takes between 10 to 15 minutes for comparable domestic stocks to reach efficiency, which is significantly faster than ADRs. On the other hand, ADRs are different from U.S. domestic firms in that they are from foreign countries with possibly very different legal, judicial, political, accounting, or corporate governance institutions. When we explore the determinants of the speed of convergence to market efficiency for ADRs, these differences enable us to examine whether such institution variables, in addition to trading and firm characteristics, are correlated with the speed to market efficiency.

Chordia, Roll, and Subrahmanyam (2005) is the first study on the speed of convergence to market efficiency. They study a sample of 150 U.S. domestic stocks and focus on documenting the speed to market efficiency. Our study complements Chordia et al. (2005) by investigating ADRs of foreign firms and using more recent data. We also try to extend Chordia et al. (2005) by exploring the factors affecting the speed to market efficiency. Among the trading and firm characteristics, we find

that stock price, volatility, and trading volume are significantly negatively related to the time needed to reach efficiency. In addition, country-level institutions make a difference. ADRs of firms from countries of common-law legal origin, or with better judicial efficiency, political stability, accounting standards, and anti-director rights are faster to reach market efficiency. Moreover, these institution variables seem to be able to explain some of the difference in the speed of convergence to market efficiency between the ADRs and U.S. domestic stocks.

The remainder of the paper is organized as follows: We describe the sample and data in Section 2. Tests and results on the speed of convergence to market efficiency are presented in Section 3. We explore the factors affecting the speed in Section 4. Section 5 gives concluding remarks.

2. Sample and data

On the NYSE's list of non-U.S. issuers, there were 489 listings from 460 issuers as of December 28, 2004. Some listings are from firms incorporated in "flag-of-convenience" countries, which are not their real place of operations. Following Pulatkonak and Sofianos (1999) and Bacidore and Sofianos (2002), we delete them from our sample. [3] In addition to common stocks, preferred stocks, exchange traded funds, and global (depository) shares are listed on the NYSE. [4] They are excluded from the sample. Among the remaining stocks, 320 from 39 countries have data for the analyses and comprise our final sample.

[3] The following are the countries and the number of listings deleted: Bahamas, 2; Bermuda 29; Cayman Islands, 4; Guernsey, 1; Liberia, 1; Netherlands Antilles, 1; Panama, 2; Puerto Rico, 6.

[4] Global shares are designed to raise capital in multiple international markets and are very different from ADRs. For details, see Karolyi (2003).

Our sample period covers the year of 2005. Country-level data are from La Porta et al. (1999, 1998) and Eleswarapu and Venkataraman (2006). Firm-level data are from Compustat, CRSP, and Datastream. Intraday transactions data, including trade prices and bid and ask quotes, are collected from the exclusive Reuters dataset maintained by SIRCA.[5]

Table 1 presents the geographical distribution, firm and countries statistics for sample firms. Canada and the United Kingdom top the list with 56 and 35 stock listings, respectively. This accords with the argument that cultural, economic, and geographical proximity significantly influences the choice of foreign listing locations (see Bruner et al., 2000 and Sarkissian and Schill, 2004). Following Bruner et al. (2000), we use familiarity, a dummy variable equal to one if a listing is from a country sharing a common border, language, or culture with the U.S., to capture this effect. Across the sample firms, there is salient variation in the fraction of trading taking place on the NYSE, from the lowest of less than 1%[6] (the U.K.) to the highest of 97% (Peru). On average, the NYSE retains about 27% of the combined trading at home and the NYSE. Benchmarked with an average stock on the NYSE, sample firms have a lower stock price ($29 versus $36), very similar daily return volatility (1.7% versus 1.6%), larger size in terms of market value of equity (about $20 billion

[5] SIRCA stands for Securities Industry Research Centre of Asia-Pacific. For details, see www.sirca.org.au

[6] There is still a substantial amount of trading on the NYSE. The average daily volume is about $16 million for a U.K. stock.

versus about $8 billion), and lower daily trading volume (about $11 million versus about $21 million).[7]

Our sample of international issuers shows substantial divergence in legal, judicial, political, accounting, and corporate governance institutions. Forty percent of the firms are from a country of common-law legal origin, which has stronger legal protection of investors, while the rest are from civil-law countries. Judicial efficiency assesses "the efficiency and integrity of the legal environment as it affects business" (La Porta et al., 1998). In our sample, Indonesia is rated the least efficient (2.5 out of the full rating of 10). However, many countries have a score of 10, the most efficient enforcement of law. The rating on the political stability ranges from 48 (Indonesia) to 95 (Luxembourg). The average score of political stability is approximately 81 (out of 100). Accounting standards assess the accounting quality by examining and rating companies' inclusion or omission of 90 accounting items across 7 categories on their annual reports (see La Porta et al., 1998). The highest rating is 78 (Singapore and the U.K.), more than twice as large as the lowest score of 36 (Portugal). Anti-director rights measure the presence of 6 important corporate governance mechanisms. The rating ranges from 0 (Belgium) to 5 (6 countries). In comparison with the U.S., sample firms' home countries, on average, have lower institutional quality. [8]

[7] The average stock price and daily trading volume for NYSE firms are estimated from NYSE statistics. The average daily return volatility is calculated using CRSP data. The market value of equity at the end of 2005 is from Compustat.

[8] To put it in perspective, the U.S. is a common-law country with high ratings: judicial efficiency (10), accounting standards (71), and anti-director rights (5).

3. The speed of convergence to market efficiency

3.1. The speed for foreign stocks on the NYSE

In an efficient market where stock prices fully and readily reflect relevant information, past trading information cannot be used to predict future returns. Therefore, the short-horizon return predictability of past trading information is an inverse indicator of the market efficiency. In this line of thinking, Chordia et al. (2005) originate an ingenious way to measure how long it takes to achieve weak-form efficiency. They regress intraday short-horizon returns on lagged returns and lagged order imbalances over intervals of the same length for intervals of 5, 10, 15, 30, and 60 minutes. If the past returns and order imbalances cannot predict returns over a particular time interval (e.g., 30 minutes), then trading achieves efficiency within the length of the interval (that is, the speed of convergence to market efficiency is within 30 minutes). To measure the speed of convergence to market efficiency for foreign stocks, we follow the method in Chordia et al. (2005). Specifically, we run the following regression for each stock:

$$\mathrm{Re}t_t = \beta_1 \mathrm{Re}t_{t-1} + \beta_2 OIBD_{t-1} (or\ OIBN_{t-1}) + \varepsilon_t \quad (1)$$

For every stock, a separate regression is run for each of the following time intervals over 2005: 5, 10, 15, 30, 60, 90, and 120 minutes. The return over a time interval, $\mathrm{Re}t_t$, is calculated from the midpoint of the bid and ask quotes closest to the end of the time interval. The midpoint returns are free from the serial correlations induced by the bid-ask bounce. $\mathrm{Re}t_{t-1}$ is the lagged return. To measure order imbalance, Lee and Ready (1991) algorithm is used to determine whether a trade is

buyer or seller initiated. Two measures of order imbalance are calculated. $OIBD_{t-1}$, order imbalance in dollars, is the total dollar amount paid by buyer-initiators minus the total dollar amount received by seller-initiators during the lagged time interval. $OIBN_{t-1}$, order imbalance in numbers, is the number of buyer-initiated trades minus the number of seller-initiated trades during the lagged time interval. The first interval of each day is excluded from regressions because lagged variables are needed.

Regression results for NYSE foreign stocks are presented in Panels A and D of Table 2. Results suggest that, on average, it takes more than 30 minutes but less than 60 minutes for a foreign stock to achieve efficiency. Whether order imbalance in dollars (Panel A) or in numbers (Panel D) is used, the past return and order imbalance lose their predictive power after 30 minutes.

3.2. The difference in speed between foreign and U.S. stocks

To better understand the results, we need to put this speed in perspective. A natural benchmark is domestic U.S. firms. We expect that it takes more time for foreign stocks traded on the NYSE to achieve efficiency than comparable domestic U.S. stocks traded on the same exchange for the following reasons. First, Chordia et al. (2005) find that the process to market efficiency is closely related to trading activities of the NYSE specialists. Specialists may behave very differently in the trading of foreign stocks on the NYSE. Indeed, Bacidore and Sofianos (2002) document that specialists' closing inventory positions for foreign stocks are closer to zero than comparable U.S. stocks, and specialists are less willing to participate in or

stabilize the trading of foreign stocks from emerging markets. The difference may lead to slower convergence to market efficiency for foreign stocks. Second, Chordia, Roll, and Subrahmanyam (2007) examine the time variation in the predictive relation between returns and past trading information. They find that liquidity reduces the return predictability from past order flows and thus enhances market efficiency. Studies indicate that significant difference exists between the liquidity of foreign stocks and U.S. stocks. Bacidore and Sofianos (2002) find that foreign stocks on the NYSE have wider spreads, less depth, and greater transitory volatility than U.S. stocks. Bacidore, Battalio, Caplin, and Jennings (2005) observe that NYSE foreign stocks have less displayed (quoted) liquidity both in the limit-order book and on the floor and also less total liquidity (displayed and non-displayed liquidity) than comparable US stocks. Given the less liquidity, the speed of convergence to market efficiency for foreign stocks on the NYSE should be slower than that for comparable US stocks.

To test this hypothesis, for each foreign stock, we select a U.S. stock listed on the NYSE as a control. Following Bacidore and Sofianos (2002) and Eleswarapu and Venkataraman (2006), the control firms are matched on industry, stock price, market capitalization, and volatility. We first identify all U.S. firms with the same first two digits of the SIC code. The control firm is the one that minimizes the following:

$$\sum_{i=1}^{3}\left(\frac{X_I^{U.S.} - X_i^{foreign}}{((X_I^{U.S.} + X_i^{foreign})/2)}\right)^2 \qquad (2)$$

where X_i is one of the matching characteristics.

We then run the same multivariate regressions (Equation 1) to examine the speed of convergence to efficiency for the control sample of U.S. stocks.

Panels B and E in Table 2 demonstrate that, on average, U.S. stocks take 10 to 15 minutes to achieve efficiency, [9] which is significantly less than the 30 to 60 minutes for foreign stocks. Table 2 also shows two other important differences. First, R-squares of regressions on foreign firms are twice as large as those of regressions on U.S. firms for all but one time interval (the 5 minute interval). That is, foreign stocks' lagged returns and order imbalances combined have predictive power twice as large as that of U.S. stocks. Second, the magnitude of the coefficients for lagged returns and order imbalances is much larger for foreign stocks than that for U.S. stocks. We run both parametric t-test and nonparametric sign test to test the difference. Results in Panels C and F show that the differences are highly significant across all time intervals. Overall, the evidence shows that it takes significantly more time for foreign stocks to achieve market efficiency than comparable U.S. firms.

4. Factors affecting the speed

4.1. Results from cross-sectional regressions

To explore the factors affecting the speed of convergence to market efficiency, we run the following cross-sectional regressions:[10]

[9] This is based on the 5% level of significance. If the 10% level of significance is used, it takes more than 15 minutes but less than 30 minutes.

[10] Most of the explanatory variables are used in Eleswarapu and Venkataraman (2006) to analyze trading costs.

$$Speed_i = \beta_1 \text{home market share}_i + \beta_2 \text{ inverse price}_i + \beta_3 \text{ volatility}_i + \beta_4 \text{ market cap}_i + \beta_5 \log \text{volume}_i + \beta_6 \text{ institutional quality}_i + \varepsilon_i \quad (3)$$

The dependent variable, the speed, is an ordinal variable that takes the value of 1, 2, 3, 4, 5, 6, 7, or 8 when the lagged return and order imbalance measures cannot predict the current return during the 5, 10, 15, 30, 60, 90, 120, or more than 120 minutes intervals, respectively. A lower value of the dependent variable indicates a higher speed to market efficiency.

The explanatory variables include firm and country characteristics. Home market share is the average ratio of daily trading volume at the home market to the sum of daily volume on the NYSE and at home. Domowitz, Glen, and Madhavan (1998) find that the effects of international cross-listings on market quality include both the benefit from increased intermarket and the costs of order flow diversion. The net effects are complex and depend on the quality of the intermarket informational linkages between the home and the destination country. On one hand, a larger portion of the trading in the home market may increase the competition to NYSE traders and hence increase the market efficiency if the information linkage between the home market and the U.S. market is transparent. On the other hand, if the information linkage is very poor, a larger portion of trading in the home market means a diversion of order flow from the U.S. market and hence adversely affects the market efficiency. Therefore, the sign of β_1 is an empirical issue. Market mircrostructure literature establishes a negative relation between price and trading costs and also between volume and trading costs (Stoll 2003). Therefore, we

expect β_2, the coefficient of the inverse price, to be positive and β_5, the coefficient of volume, to be negative, because higher trading costs (lower liquidity) adversely affect market efficiency (Chordia, Roll, and Subrahmanyam, 2007). Ross (1989) finds that volatility is directly related to the rate of flow of information to the market. Larger companies are usually considered to have a better information environment and less information asymmetry. Therefore, we expect that these two variables are negatively related to the dependent variable.

Studies find that the institutional quality of a country greatly affects firms operating in the country. La Porta et al. (2002) find that firms in countries with better protection of minority shareholders have higher valuation. Firms in countries with stronger investor protection also tend to have higher dividend payouts (La Porta et al. 2000). Chung (2006) studies the relationship between investor protection and firm liquidity. He finds that ADRs of firms from countries with better investor protection have both lower information asymmetry costs and higher liquidity. Eleswarapu and Venkataraman (2006) find that in addition to investor protection, other macro-level institutions significantly affect equity trading costs through their effect on information risk and investor participation. They find that ADRs if firms operating in countries of common law legal origin, with better ratings for judicial efficiency, political stability, and accounting standards have significantly lower trading costs. Based on the above findings that better institutions improves liquidity and the evidence in Chordia et al. (2007) that liquidity facilitates market efficiency, we expect the institutional variables are negatively related to the speed of

convergence to market efficiency. Following Eleswarapu and Venkataraman (2006), the institutional quality is measured by the following variables:[11] legal origin, a dummy variable that takes the value of one if the home country has a civil-law legal origin and zero otherwise. Because civil-law countries tend to have weaker legal institutions, we expect a positive relationship between this dummy variable and the speed to efficiency. Judicial efficiency, political stability, accounting standards, and anti-director rights are proxies for the quality of the judicial, political, accounting, and corporate governance institutions. Better ratings indicate higher quality. We expect a negative coefficient for these variables. Familiarity is a dummy variable that is equal to one if the home country has a common border, language, or culture with the U.S. We expect a negative relationship between familiarity and the speed to efficiency, because Bruner, Chaplinsky, and Ramchand (2000) find that these attributes serve to mitigate the risk of asymmetric information.

The cross-sectional regression results are presented in Table 3. The speed is estimated using lagged order imbalance in dollars (Panel A) or in numbers (Panel B). The results are generally consistent with our expectations. The portion of trading taking place in the home market does not significantly affect the speed to efficiency. Stocks with higher price, volatility, and trading volume tend to be more efficient. It takes significantly less time for stocks of foreign firms operating in countries of common-law legal origin, with better ratings of judicial efficiency, political stability, accounting standards, or anti-director rights to achieve market efficiency. Stocks of

[11] The country-level variables are not used simultaneously in the regressions because they are highly correlated.

firms from countries sharing a common border, language, or culture with the U.S. also enjoy faster speed of convergence to market efficiency.

4.2. Robustness checks

4.2.1. The speed measured in transactions

We have measured the speed of convergence to market efficiency in calendar time. It is also interesting to measure the speed by the number of transactions. That is, how many trades does it take the stock price of a sample firm or its control firm to fully incorporate trade-related information? To answer this question, we run the following VAR models from Dufour and Engle (2000):

$$r_t = \sum_{i=1}^{5} a_i r_{t-i} + \lambda^r_{open} D_t x^0_t + \sum_{i=0}^{5} (\gamma^r_i + \delta^r_i \ln(T_{t-i})) x^0_{t-i} + v_{1,t}$$

$$x^0_t = \sum_{i=1}^{5} c_i r_{t-i} + \lambda^x_{open} D_{t-1} x^0_{t-1} + \sum_{i=1}^{5} (\gamma^x_i + \delta^x_i \ln(T_{t-i})) x^0_{t-i} + v_{2,t} \quad (4)$$

where r_t is the quote change after the trade in t. x^0_{t-i} is the trade indicator (1 for a buy and -1 for a sale). D_t is a dummy variable that equals to one if the trade is in the first 30 minutes of the trading day and zero otherwise. T_t is the time in seconds between two consecutive transactions (+1 second). Using transactions data for the year of 2005, the VAR model is run for every foreign firm on the NYSE and its U.S. control firm. The speed to efficiency is measured by the number of trades before one standard deviation shock in the trade indicator has been absorbed in mid-quote returns, which is calculated from the impulse response function based on the bivariate VAR models.

Table 4 shows the results. On average, it takes about 27 trades for a foreign stock to reach efficiency, while just 20 trades for a U.S. control stock. The average difference in the speed to efficiency between a foreign stock traded on the NYSE and its U.S. control stock is 8 trades, which is statistically significant at the 1% level. The median speed is 23 and 20 trades for a foreign stock and its U.S. control stock, respectively. The difference in the median speed is also statistically significant at the 1% level. The results in Table 4 corroborate the finding in Table 2 that it takes more time for a foreign stock to reach market efficiency than a comparable U.S. stock.

4.2.2. The effect of residual differences between sample and control firms

The significant difference in the speed to market efficiency between foreign and their U.S. control stocks may be due to residual differences between these two groups of firms. To address this concern, we run the following regression, which is based on the similar methodology in Bacidore and Sofianos (2002) and Eleswarapu and Venkataraman (2006):

$$D\ Speed_i = \beta_0 + \beta_1 \text{hom}e\ market\ share_i + \beta_2\ D\ inverse\ price_i + \beta_3\ D\ volatility_i + \beta_4\ D\ market\ cap_i + \beta_5 D\ volume_i + \beta_6\ institutional\ quality_i + \varepsilon_i \quad (5)$$

where $D\ Speed_i$ is the difference in the speed of convergence to market efficiency between foreign stock i and its U.S. control stock. The speed is measured by the natural logarithm of the number of trades before one standard deviation shock in the trade indicator has been absorbed in mid-point returns. The number of trades is calculated from the impulse response function based on the VAR models from Dufour and Engle (2000). D inverse price, D volatility, D market cap, and D volume are calculated as the difference in the respective firm characteristic scaled by the

sum of that characteristic. Home market share and institutional quality variables are the same as in Regression (3).

Table 5 presents the results. The focus is on β_0. If the difference in speed to market efficiency between foreign and U.S. control stocks is not due to the residual differences between the two groups, β_0 should be significantly positive. Results indicate that β_0 is positive in all regressions and statistically significant at the 1% level in 6 out of the 7 regression specifications. This shows that the slower speed of foreign stocks is not due to the residual differences between foreign firms and their U.S. control firms. The coefficients for most of the country-level variables are also of the expected sign. Among them, judicial efficiency, political stability, and accounting standards are significantly negatively related to the difference in the speed to market efficiency at the 5% level, which suggest that the differences in the institutional quality between foreign firms' home countries and the U.S. can explain some of the differences in their speed to market efficiency.

5. Concluding remarks

In this paper, we document the speed of convergence to market efficiency for foreign stocks listed on the NYSE. We find that on average it takes between 30 and 60 minutes for an ADR to achieve market efficiency. For a comparable U.S. stock listed on the same exchange, it takes only 10 to 15 minutes. The significant difference in the speed to market efficiency between foreign and U.S. stocks remains robust when the speed is measured by the number of transactions instead of in calendar time. We try to identify the factors affecting the speed among various

trading, firm, and country characteristics. We find that factors associated with information asymmetry and investor participation significantly affect the speed to market efficiency for foreign stocks. Specially, foreign stocks with higher price, volatility, and trading volume and stocks of foreign firms operating in countries with better legal, judicial, political, accounting, and corporate governance institutions take significantly less time to converge to market efficiency.

This study contributes to the cross-listing literature by providing evidence on the intraday market efficiency of foreign stocks traded in the U.S. The results suggest that measures reducing information asymmetries of foreign stocks, facilitating the informational linkage between foreign countries and the U.S., or improving the macro-level institutional quality in foreign countries are likely to improve the efficiency of markets for foreign stocks traded in the U.S.

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Table 1
Sample characteristics

Country /District	No	Home market share	Price	Volatility	Market cap	Volume	Legal origin	Judicial efficiency	Political stability	Accounting standards	Anti-director rights	Familiarity
Argentina	8	0.41	16.94	0.022	3,455	1,093,211	1	6	62.5	45	4	0
Australia	7	0.95	57.97	0.015	25,879	6,887,156	0	10	88.5	75	4	1
Austria	1	0.99	40.14	0.013	11,150	161,550	1	9.5	89.5	54	2	0
Belgium	1	0.93	64.26	0.016	6,200	1,205,203	1	9.5	87	61	0	0
Brazil	9	0.39	25.55	0.025	18,095	25,597,528	1	5.75	62.5	54	3	0
Canada	56	0.60	28.57	0.019	8,794	16,503,557	0	9.25	89.5	74	5	1
Chile	15	0.59	32.67	0.014	3,116	1,627,630	1	7.25	77.5	52	5	0
China	15	0.86	29.25	0.017	6,226	5,185,359	1	NA	68	NA	NA	0
Denmark	1	0.94	53.21	0.014	16,938	2,336,222	1	10	91	62	2	0
Finland	4	0.91	18.05	0.014	26,041	43,380,758	1	10	95	77	3	0
France	17	0.96	26.92	0.016	33,351	10,924,272	1	8	80.5	69	3	0
Germany	13	0.47	34.68	0.015	33,116	9,036,250	1	9	87.5	62	1	0
Greece	4	0.97	20.64	0.017	8,047	2,356,732	1	7	76	55	2	0
Hong Kong	8	0.78	13.48	0.019	13,464	2,207,358	0	10	80.5	69	5	0
Hungary	1	0.93	22.93	0.020	4,595	426,892	1	NA	78	NA	NA	0
India	8	0.45	16.60	0.021	6,511	5,916,704	0	8	56	57	5	0
Indonesia	2	0.64	23.95	0.020	7,570	4,125,181	1	2.5	48	NA	2	0
Ireland	3	0.64	39.15	0.030	13,390	34,455,617	0	8.75	92	NA	4	1
Israel	3	0.58	9.11	0.019	481	281,746	0	10	58.5	64	3	1
Italy	9	0.98	26.00	0.014	28,385	2,464,900	1	6.75	81	62	1	0

Table 1 (continued)

Japan	18	0.96	36.80	0.016	45,171	5,994,852	1	10	86	65	4	0
Korea	8	0.77	34.58	0.019	17,599	13,796,687	1	6	76	62	2	0
Luxembourg	1	NA	17.19	0.026	13,517	40,188,123	1	NA	95	NA	NA	0
Mexico	12	0.39	18.14	0.019	7,036	15,866,103	1	6	68	60	1	1
Netherlands	15	0.77	19.13	0.016	20,264	7,374,511	1	10	94	64	2	0
New Zealand	1	0.88	34.26	0.011	8,009	3,571,383	0	10	91	70	4	1
Norway	3	0.94	15.39	0.019	26,284	4,670,198	1	10	89.5	74	4	0
Peru	2	0.03	22.91	0.021	3,020	6,511,498	1	6.75	65	38	3	0
Philippines	1	0.41	28.27	0.013	6,051	6,236,541	1	4.75	67	65	3	0
Portugal	2	0.97	19.23	0.011	11,517	1,061,580	1	5.5	84.5	36	3	0
Russia	6	0.11	29.54	0.023	6,914	15,283,736	**1**	**NA**	**61.5**	**NA**	**NA**	0
Singapore	1	NA	10.66	0.049	277	4,457,165	0	10	90	78	4	0
South Africa	6	0.62	28.81	0.022	10,951	12,544,666	0	6	64	70	5	0
Spain	5	0.98	25.95	0.011	56,063	5,283,428	1	6.25	82.5	64	4	0
Switzerland	12	0.94	33.18	0.014	28,279	14,094,834	1	10	92.5	68	2	0
Taiwan	5	0.70	9.65	0.019	18,236	26,128,244	1	6.75	79.5	65	3	0
Turkey	1	0.78	11.51	0.024	11,403	6,772,770	1	4	58.5	51	2	0
United Kingdom	35	1.00	39.46	0.013	38,186	15,727,054	0	10	**90**	78	5	**1**
Venezuela	1	NA	16.95	0.023	875	4,664,194	1	6.5	49.5	40	1	0
Average	NA	0.73	28.78	0.017	19,668	11,442,446	NA	8.50	81.26	66.33	3.62	NA

This table shows by the home country the firm and country characteristics for foreign firms listed on the NYSE. The sample period covers the year of 2005. No. is the number of foreign firms from that country that are listed on the NYSE. Firm characteristics are the average across all sample firms from a foreign country. Home market share is the average ratio of daily trading volume at the home market to the sum of daily volume on the NYSE and at home. Price is the average daily stock price. Volatility is the standard deviation of daily returns. Market cap is the market capitalization in millions of U.S. dollars at the end of 2005. Volume is the average daily volume in U.S. dollars on the NYSE. Legal origin is a dummy variable that is equal to one if the home country has civil-law legal origin and zero otherwise. The classification of legal

origins is based on La Porta et al. (1999). Judicial efficiency, a rating from 0 to 10, accounting standards, a rating from 0 to 100, and anti-director rights, a rating from 0 to 6, are from La Porta et al. (1998). Political stability ranges from 0 to 100 and is from Eleswarapu and Venkataraman (2006). Higher ratings indicate better judicial, accounting, corporate governance, and political institutions at the home country. Familiarity is a dummy variable that equals to one if the home country has a common border, language, or culture with the U.S. and zero otherwise.

Table 2

Speed of convergence toward market efficiency

Explanatory Variables	5 minutes	10 minutes	15 minutes	30 minutes	60 minutes	90 minutes	120 minutes
Panel A. Foreign firms							
$\mathrm{Re}t_{t-1}$	**-0.095**	**-0.103**	**-0.099**	**-0.093**	-0.027	-0.032	-0.036
	(-3.989)	(-3.506)	(-3.112)	(-2.493)	(-1.067)	(-1.093)	(-1.107)
$OIBD_{t-1}$	2.877	2.389	2.344	1.724	1.775	1.349	1.632
	(1.080)	(0.623)	(0.587)	(0.344)	(0.045)	(-0.033)	(-0.154)
R^2	0.028	0.035	0.036	0.036	0.009	0.012	0.016
Panel B. U.S. control firms							
$\mathrm{Re}t_{t-1}$	**-0.080**	**-0.065**	**-0.068**	-0.058	-0.018	-0.010	-0.019
	(-2.928)	(-1.968)	(-1.865)	(-1.411)	(-0.688)	(-0.365)	(-0.606)
$OIBD_{t-1}$	0.314	0.303	0.254	0.272	0.334	0.172	0.279
	(0.793)	(0.544)	(0.725)	(0.382)	(0.063)	(0.048)	(-0.059)
R^2	0.022	0.018	0.019	0.018	0.005	0.006	0.008
Panel C. Difference between foreign firms and U.S.control firms							
$\mathrm{Re}t_{t-1}$(foreign-U.S.)	0.015	0.036	0.031	0.031	0.010	0.014	0.016
T-test	2.118**	5.116***	4.147***	4.361***	3.187***	4.194***	3.529***
Sign-test	2.516**	4.416***	4.304***	3.298***	2.516**	3.186***	3.857***
$OIBD_{t-1}$(foreign-U.S.)	2.748	2.640	2.328	2.503	2.706	2.747	2.902
T-test	3.636***	3.509***	3.665***	3.142***	3.110***	3.610***	3.673***
Sign-test	7.770***	6.876***	10.230***	9.895***	9.895***	1.006***	8.329***

Table 2 (continued)

Panel D. Foreign firms							
Ret_{t-1}	**-0.097**	**-0.104**	**-0.100**	**-0.094**	-0.029	-0.033	-0.037
	(-4.079)	(-3.571)	(-3.158)	(-2.549)	-1.129	-1.130	-1.134
$OIBN_{t-1}$	**5.379**	**4.695**	3.759	3.711	3.054	1.838	2.417
	3.461	2.117	1.574	1.129	0.704	0.319	-0.092
R^2	0.029	0.036	0.036	0.036	0.009	0.012	0.015
Panel E. U.S. control firms							
Ret_{t-1}	**-0.086**	**-0.068**	**-0.071**	-0.060	-0.019	-0.011	-0.019
	-3.082	-2.044	-1.910	-1.432	-0.704	-0.414	-0.620
$OIBN_{t-1}$	**1.531**	0.987	0.816	0.596	0.428	0.356	0.297
	3.148	1.566	1.350	0.751	0.156	0.166	-0.108
R^2	0.023	0.018	0.020	0.017	0.005	0.006	0.008
Panel F. Difference between foreign firms and U.S.control firms							
Ret_{t-1}(foreign-U.S.)	0.011	0.034	0.030	0.030	0.010	0.014	0.016
T-test	1.543	4.819***	3.937***	4.267***	3.110***	4.206***	3.499***
Sign-test	2.292**	4.640***	4.193***	3.298***	2.180**	3.634***	3.745***
$OIBN_{t-1}$(foreign-U.S.)	4.016	3.910	3.167	3.782	3.543	2.885	4.407
T-test	6.093***	5.764***	5.104***	5.528***	4.554***	5.672***	2.786***
Sign-test	7.659***	8.106***	7.659***	8.777***	9.000***	9.000***	7.547***

For each of the 7 time intervals, we regress the return during the interval on the lagged return and lagged order imbalances ($OIBD_{t-1}$ or $OIBN_{t-1}$) for every stock. The return is calculated from the midpoint of the bid and ask quotes closest to the end of the time interval. $OIBD_{t-1}$ is the total dollar amount paid by buyer-initiators minus the total dollar amount received by seller-initiators during the lagged time interval. $OIBN_{t-1}$ is the number of buyer-initiated trades minus the number of seller-initiated trades during the lagged time interval. The first interval of each day is

excluded. The regression is run for each stock for the year of 2005. Average coefficients, t-statistics (in the bracket), and R-squared are reported for foreign firms listed on the NYSE (Panels A and D) and for U.S. control firms (Panels B and E). Coefficients for the order imbalance measures are multiplied by 10^5. Panels C and F report the difference between the coefficients for foreign and U.S. firms and statistics from tests (t test and sign test) of the null hypothesis that the coefficients for foreign and U.S. firms are equal. Three and two asterisks indicate significance at 1% and 5% level, respectively.

Table 3
Determinants of speed of convergence to efficiency for foreign firms
Panel A. Speed based on OIB dollar.

Explanatory Variables	1	2	3	4	5	6	7
Home market share	-0.025 (0.918)	0.033 (0.893)	0.226 (0.378)	0.010 (0.967)	0.334 (0.222)	0.160 (0.539)	0.006 (0.981)
Inverse price	4.678 (0.009)	4.672 (0.008)	4.333 (0.012)	4.693 (0.009)	5.627 (0.001)	4.287 (0.012)	4.781 (0.007)
Volatility	-44.594 (0.042)	-44.262 (0.049)	-45.094 (0.055)	-45.331 (0.054)	-77.092 (0.000)	-42.413 (0.052)	-46.048 (0.048)
Market cap	0.000 (0.723)	0.000 (0.918)	0.000 (0.963)	0.000 (0.727)	-0.000 (0.558)	-0.000 (0.823)	0.000 (0.918)
Log volume	-0.388 (0.000)	-0.356 (0.001)	-0.356 (0.001)	-0.381 (0.000)	-0.302 (0.006)	-0.341 (0.001)	-0.359 (0.000)
Legal Origin		0.223 (0.090)					
Judicial Efficiency			-0.078 (0.041)				
Political Stability				-0.002 (0.720)			
Accounting Standards					-0.021 (0.006)		
Anti-director Rights						-0.082 (0.060)	
Familiarity							-0.258 (0.062)
Pseudo- R-squared	0.059	0.061	0.062	0.059	0.079	0.062	0.062

Panel B. Speed based on OIB number

Explanatory Variables	1	2	3	4	5	6	7
Home market share	-0.416 (0.094)	-0.359 (0.146)	-0.252 (0.334)	-0.236 (0.353)	-0.146 (0.588)	-0.339 (0.188)	-0.382 (0.124)
Inverse price	3.594 (0.036)	3.588 (0.029)	3.655 (0.028)	3.692 (0.028)	4.314 (0.010)	3.618 (0.029)	3.696 (0.027)
Volatility	-27.273 (0.041)	-26.797 (0.051)	-32.907 (0.029)	-31.097 (0.048)	-48.455 (0.000)	-29.939 (0.030)	-28.715 (0.044)
Market cap	0.000 (0.844)	-0.000 (0.921)	-0.000 (0.977)	0.000 (0.869)	-0.000 (0.551)	-0.000 (0.742)	-0.000 (0.886)
Log volume	-0.285 (0.003)	-0.250 (0.008)	-0.240 (0.014)	-0.253 (0.008)	-0.175 (0.079)	-0.225 (0.023)	-0.248 (0.008)
Legal Origin		0.230 (0.078)					
Judicial Efficiency			-0.090 (0.012)				
Political Stability				-0.012 (0.031)			
Accounting Standards					-0.020 (0.009)		
Anti-director Rights						-0.081 (0.057)	
Familiarity							-0.299 (0.026)
Pseudo- R-squared	0.030	0.033	0.036	0.034	0.041	0.034	0.035

This table shows the results from cross-sectional regressions of the speed to efficiency for foreign firms listed on the NYSE on their firm and country characteristics. The dependent variable, speed to efficiency, takes the value of 1, 2, 3, 4, 5, 6, 7, and 8 if the lagged return and order imbalance measures (order imbalance in dollars in Panel A and order imbalance in numbers in Panel B) cannot predict the current return during the 5, 10, 15, 30, 60, 90, 120, and more than 120 minutes time intervals, respectively. Home market share is the average ratio of daily trading volume at the home market to the sum of daily volume on the NYSE and at home. Inverse price is the inverse of the average daily price. Volatility is the standard deviation of daily returns. Market cap is the market capitalization at the end of 2005. Log volume is the logarithm of average daily volume on

the NYSE. Legal origin is a dummy variable that is equal to one if the home country has civil-law legal origin and zero otherwise. The classification of legal origins is based on La Porta et al. (1999). Judicial efficiency, a rating from 0 to 10, accounting standards, a rating from 0 to 100, and anti-director rights, a rating from 0 to 6, are from La Porta et al. (1998). Political stability ranges from 0 to 100 and is from Eleswarapu and Venkataraman (2006). Higher ratings indicate better judicial, accounting, corporate governance, and political institutions at the home country. Familiarity is a dummy variable that equals to one if the home country has a common border, language, or culture with the U.S. and zero otherwise.

Table 4
Difference in the speed of convergence to market efficiency between foreign and U.S. control firms when the speed is measured by the number of trades

Speed in number of trades	Sample	Control	Sample-Control
Mean	27	20	8
t-test statistic	6.223***		
Median	23	20	3
Wilcoxon signed rank test statistic	9.878***		

The dependent variable is the difference in the speed of convergence to efficiency between foreign firms listed on the NYSE and U.S. control firms. The speed is measured by the number of trades before one standard deviation shock in the trade indicator has been absorbed in mid-point returns. The number of trades is calculated from the impulse response function based on the following VAR models from Dufour and Engle (2000):

$$r_t = \sum_{i=1}^{5} a_i r_{t-i} + \lambda^r_{open} D_t x^0_t + \sum_{i=0}^{5} (\gamma^r_i + \delta^r_i \ln(T_{t-i})) x^0_{t-i} + v_{1,t}$$

$$x^0_t = \sum_{i=1}^{5} c_i r_{t-i} + \lambda^x_{open} D_{t-1} x^0_{t-1} + \sum_{i=1}^{5} (\gamma^x_i + \delta^x_i \ln(T_{t-i})) x^0_{t-i} + v_{2,t}$$

where r_t is the quote change after the trade in t. x^0_{t-i} is the trade indicator (1 for a buy and -1 for a sale). D_t is a dummy variable that equals to 1 if the trade is in the first 30 minutes of the trading day and zero otherwise. T_t is the time in seconds between two consecutive transactions (+1 second). Using transactions data for the year of 2005, the VAR model is run for every foreign firm on the NYSE and its U.S. control firm.

T-test tests the null hypothesis that the average speed for sample firms equals to that for control firms. Wilcoxon signed rank test tests the null that the median speed for sample firms equals to that for control firms. *** indicates the 1% level of significance.

Table 5
Cross-sectional regressions of difference between foreign and U.S. control firms

Explanatory Variables	1	2	3	4	5	6	7
Intercept	0.294	0.267	0.553	0.784	0.881	0.229	0.354
	(0.004)	(0.005)	(0.008)	(0.002)	(0.005)	(0.149)	(0.003)
Home Market Share	0.020	0.048	0.220	0.166	0.319	0.106	0.061
	(0.872)	(0.708)	(0.074)	(0.210)	(0.017)	(0.357)	(0.637)
Differential Inverse price	-0.075	-0.073	-0.005	-0.074	0.004	-0.003	-0.080
	(0.617)	(0.627)	(0.972)	(0.619)	(0.975)	(0.986)	(0.592)
Differential Volatility	-0.514	-0.544	-0.560	-0.541	-0.577	-0.527	-0.578
	(0.150)	(0.135)	(0.137)	(0.127)	(0.155)	(0.160)	(0.117)
Differential Market cap	-0.414	-0.440	-0.451	-0.442	-0.454	-0.402	-0.463
	(0.030)	(0.022)	(0.026)	(0.021)	(0.026)	(0.051)	(0.018)
Differential Volume	0.062	0.106	0.170	0.142	0.293	0.110	0.134
	(0.648)	(0.480)	(0.212)	(0.326)	(0.066)	(0.456)	(0.365)
Legal Origin		0.067					
		(0.273)					
Judicial Efficiency			-0.039				
			(0.049)				
Political Stability				-0.007			
				(0.013)			
Accounting Standards					-0.010		
					(0.018)		
Anti-director Rights						0.010	
						(0.656)	
Familiarity							-0.090
							(0.141)
Adj. R-squared	0.006	0.007	0.017	0.022	0.022	0.001	0.010

The dependent variable is the difference in the speed of convergence to efficiency between foreign firms listed on the NYSE and U.S. control firms. The speed is measured by the natural logarithm of the number of trades before one standard deviation shock in the trade indicator has been absorbed in mid-point returns. The number of trades is calculated from the impulse response function based on the following VAR models from Dufour and Engle (2000):

$$r_t = \sum_{i=1}^{5} a_i r_{t-i} + \lambda^r_{open} D_t x^0_t + \sum_{i=0}^{5} (\gamma^r_i + \delta^r_i \ln(T_{t-i})) x^0_{t-i} + v_{1,t}$$

$$x^0_t = \sum_{i=1}^{5} c_i r_{t-i} + \lambda^x_{open} D_{t-1} x^0_{t-1} + \sum_{i=1}^{5} (\gamma^x_i + \delta^x_i \ln(T_{t-i})) x^0_{t-i} + v_{2,t}$$

where r_t is the quote change after the trade in t. x^0_{t-i} is the trade indicator (1 for a buy and -1 for a sale). D_t is a dummy variable that equals to 1 if the trade is in the first 30 minutes of the trading day and zero otherwise. T_t is the time in seconds between two consecutive transactions (+1 second). Using transactions data for the year of 2005, the VAR model is run for every foreign firm on the NYSE and its U.S. control firm. The explanatory variables include the same firm and country characteristics as defined in Table 3. Except the home market share, firm-level variables are the difference in the variable between foreign and U.S. control firms scaled by the sum of the variable for foreign and U.S. control firms.