Country and Cross-Border Effects in Liquidity: An Empirical Analysis of International Equity Markets

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Abstract

For a large cross-sectional of stocks from 26 developed countries other than the U.S., we provide the most comprehensive study on the common variation in liquidity in international equity markets. We find that there is prevalent evidence on the country-wide common liquidity factor. We also find the cross-sectional variation in liquidity betas are closely related to the level of bid-ask spread, firm size, trading activity, number of analysts following, earnings dispersion, and the level of investbility or public float. In addition, there exist significant cross-border causal relations in intraday aggregate liquidity factors. The cross-border effects are more significant in European markets than in the Asian markets.

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1. Introduction

Recent years witnessed a growing literature on documenting the patterns and identifying the sources of commonality in asset liquidity. This strand of research begins with the work of Chordia, Roll, and Subrahmanyam (2000), Hasbrouck and Seppi (2001), and Huberman and Halka (2001). These earlier studies document, to varying extent, that individual stocks' liquidity such as bid-ask spread, quoted depths, and quote slope co-move with market liquidity.

Since then, a number of articles investigate the commonality issue for stocks and bonds (Chordia, Sarkar, and Subrahmanyam, 2005; Darbha and Subramanian, 2005; Goyenko,2005), for stocks handled by the same specialist firm (Coughenour and Saad, 2004), for stocks traded on limit order markets (Friederich and Payne, 2002; Kempf and Mayston, 2005), for bid-ask spread component (Henker an Martens, 2002), for stocks in different countries (Stahel, 2003). Other studies examine the linkage liquidity commonality and order type correlations (Domowitz, Hansch, Wang, 2005).

The purpose of this project is to provide a comprehensive study of the commonality issue for international equity markets. Understanding the co-movement of international liquidity is important for global investors as systematic liquidity is priced (Amihud and mendelson, 1986; Brennan and Subrahmanyam, 1996; Pastor and Stambaugh, 2003). It is also important when global investors develop trading strategies that minimize the liquidity impact on local markets (Chordia, Roll, and Subrahmanyam, 2001).

Our analysis contributes to the literature in several ways. First, existing literature focuses primarily on documenting commonality patterns within a single country. Our sample covers most comprehensive range of 4,119 stocks traded in 26 developed countries (economies): Austria, Belgium, Luxembourg, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Pan European (Virt-X), Portugal, Spain, Sweden, Switzerland, United Kingdom, Australia, Hong Kong, Japan, New Zealand, Singapore, and South Korea.[1, 2] These stocks constitute the S&P/Citigroup Broad Market Index (BMI) and are of considerable interest to institutional investors. Moreover, we will not only document the commonality patterns, but also explore what are the determinants of the cross-sectional variation in liquidity betas. Existing literature is silent in this regard.

Second, there is good reason to believe that liquidity in global equity markets are related and move in response to common shocks such as international capital flows resulting from wealth effects, changes monetary policies and interest rates, and other global or country-specific information events. We extend the literature on cross-border effects in stock returns and return volatilities to cross-border linkage in liquidity dynamics.[3] To this end we construct intraday 15-minute aggregate liquidity factors for each country and investigate their relations during overlapping trading hours within the European market, within the Asia-Pacific markets, and between U.S. and non-U.S. markets.

Third, we obtain the most comprehensive tick data on 4,119 individual stocks over an average 48-day period from commercial sources. The tick data has detailed information on quote information to the nearest second. The tick data allow us to accurately construct liquidity measures such as quoted bid-ask spread for the first time in almost all developed countries. Prior

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[1] Canadian markets include the Toronto and Venture Exchanges. German markets include the Xetra , Frankfurt , Berlin, Hanseatic, Bavarian, and Baden-Wurttemberg Exchanges. Japanese markets include Tokyo, Fukuoka, Nagoya, Osaka, Japan Securities Dealers Associations, and Nippon New Market. Korean markets include the Korean Stock Exchange and KOSDAQ .

[2] Virt-X was founded in 2001 as the cross-border platform for trading major European blue chips. Virt-X is the 'home' market for trading the constituents of the Swiss Market Index (SMI), which are listed by SWX Swiss Exchange in Switzerland. Virt-X also offers trading in Europe's most liquid stocks. With 106 members (March 2005) domiciled in Switzerland, England, Germany, France, the Netherlands, Austria, Sweden, Ireland, and the USA. The sample of 27 stocks in our study are all from Switzerland.

[3] Gagnon and Karoyi (2006) provides a comprehensive survey on the price and volatility transmission across borders.

studies such as Stahel (2003) rely on liquidity measures suggested by Amihud (2002), which are less precise than those that are based on tick-by-tick data.

Our major findings can be summarized as follows. First, we find strong evidence of common factors in liquidity for most of the 26 countries in the sample. Therefore the country-effect in liquidity variation is prevalent in international equity markets. Second, liquidity betas are negatively related to the level of bid-ask spread in a reliable manner. Interestingly, the role of firm size and trading activitity depends whether the stock is fully investable or not. For fully investable stocks, larger and more actively traded stocks tend to have higher liquidity betas. This is consistent with the findings of Chordia, Roll, and Subharhmanyam (2000). For less than full investable stocks, the opposite is true. Larger and more actively traded stocks tend to have lower liquidity betas. In addition, stocks with more analysts following, higher earnings dispersion, or higher level of investability tend to have lower liquidity betas. Third, we examine whether there exists bi-directional causality effects in liquidity between the major industrialized countries in Europe, between the Euronext countries, between the Nordic countries, between the Asian-Pacific countries, and between U.S. and other countries where trading overlaps. The empirical results indicate the major industrialized countries, i.e., the United Kingdom, France, German, and Italy, and Euronext countries, i.e., France, Belgium, Netherlands, and Spain, display the strongest cross-border liquidity effects. The cross-border effects are second strongest among Nordic countries including Denmark, Finland, Norway, and Sweden. The strong cross-border effects are also found between some Asian-Pacific countries and between U.S. and some countries. But overall, the Asian-Pacific countries display weaker cross-border effects than the European countries.

The rest of the paper proceeds in the following way. Section 2 discusses the data source, constructs the sample stocks, and provides summary statistics. Section 3 presents empirical results on the intraday country factor model using 15-minute liquidity measures. Section 4 examines the cross-sectional determinants of liquidity betas. Section 5 investigates the cross-border liquidity dynamics using a vector autoregression (VAR) framework. Finally, Section 6 concludes the paper with summary of the results and a discussion of their implications.

2. Data, Sample Construction, and Summary Statistics

2.1 Data

The universe of our sample stocks is the S&P/Citigroup Global Equity Index System.[4] The system monitors and evaluates all major global stock markets. Any country with a float adjusted market capitalization of USD 1 billion or more will be eligible for inclusion in the index. The system then creates Broad Market Indices (BMI) on a country-by-country basis. On a top-down basis, within index-eligible countries, all equity share classes of every company with a free float of at least USD 100 million and a minimum value traded of USD 20 million are included in their respective country BMIs. We begin with a total of 4,437 stocks from 26 countries (regions) in the developed world. Among them, 1,898 stocks are from 19 European countries, 2,111 stocks are from Asian countries, and 428 stocks are form North America (Canada).

S&P/Citigroup provides the monthly data on market capitalization, shares outstanding, foreign exchange rates against the U.S. dollar, and industrial classifications that correspond to our sample period.

We obtain the tick data for these stocks from commercial sources. The data contain the security identifier (SEDOL), trading date, time of bid and ask tick to the nearest second, bid

[4] See *S&P/Citigroup Global Equity Indices* for the construction of the indices.

price, bid size, ask price, ask size, transaction price, transaction size, exchange code, and condition code of bid and ask ticks. The sample period is from September 23 – December 3, 2004. The number of trading day ranges from 46 to 50 for 26 countries, with the average being 48 trading days.

We collect the intraday trading hours and tick size schedules from the webpage of each stock exchange.[5] We also collect the sample of stocks splits and minimum trading unit changes from Bloomberg News Services. The data contain the announcement date, effective date, adjustment factor of the split or MTU change, and the SEDOL of the stock that conduct the event.

2.2 Sample construction

The sample begins with 4,437 stocks from 26 countries (regions) in the S&P/Citigroup BMIs. We apply the following filtering rules to eliminate certain stocks,

(a) Large-price stocks.

We calculate the average daily closing price for each stock and compare with the tick size schedule to obtain the distribution of the sample stocks in each country. Since large price will have impact on the level and changes in percentage spread measures, we are inclined to eliminate these stocks. On the other hand, we also hope to maintain a relatively large sample size for the empirical work to be representative. On balance, the following rules are applied to stocks in Canada (300 Canadian dollars), Denmark (5,000 Danish Crown), stocks quoted in Euros (500 Euros)[6], Japan (30,000 Yen), Korea (500,000 Won), Virt-X and Switzerland

[5] The details of each exchange can be found in http://www.world-exchanges.org.

[6] Stocks quoted in Euros are from Euronext (Belgium, France, Netherlands, Portugal), Austria, Finland, Germany, Greece, Ireland, Italy, Luxembourg, and Spain.

(5,000 CHF). Overall, 125 large-price stocks are eliminated, among them. The majority (112) is from Japan.

(b) Infrequently traded stocks.

For stocks that are infrequently traded, the bid-ask spreads will not be representative. Therefore we calculate the average daily number of trades for each stock over the sample period and eliminate those stocks with fewer than 5 transactions on average. The criteria result in the exclusion of an additional 132 stocks in total.

(c) Significant portion of large percentage quoted spread.

Since the tick by tick quoted spread will be aggregated at daily level, to minimize the impact of those stocks with a significant portion of large percentage quoted spreads, we tabulation the distribution of percentage quoted spread that is large than 10% in each country. Indeed, for certain stocks, there can be as many as 20-50 percent of quoted spreads that are larger than 10%. As result, these stocks are further exclude from our sample. This criteria result in a total of 29 additional stocks eliminated.

(d) Stock splits and minimum trading unit changes

Some firms conduct stock splits or changes in minimum trading units. Both have significant impact on percentage spread measures. Therefore we conduct on comprehensive search to find the stocks in these 26 countries that conduct either splits for MTU changes during the 4-month sample period. Among them 32 stocks are also present in our sample. These stocks are further exclude from our sample.

Panel A of Table 1 summarizes the number of stocks in each country to begin with and the number of stocks eliminated following each of the above four filters. The last column in Panel A indicates the eventual number of sample stock from each country. In the end, a total of 4,119 stocks from 26 countries are retained. Among them, Japan has the largest number of stocks (1,248), followed by UK (532), Canada (407), Australia (234), France (198), South Korea (189), Germany (151), Italy (149), Hong Kong (146), and Sweden (116).

2.3 Summary statistics

2.3.1 Industrial classification

Panel B of Table 1 provides the distribution of industrial classification for each region and each country. The industrial classification is from S&P/Citigroup. All firms are categorized into the following 12 industries: basic materials (BAM), consumer cyclicals (CCY), conglomerates (CGL), consumer non-cyclicals (CNC), energy (ENY), financials (FIN), healthcare (HCR), industrial goods and services (IGS), technology (TEC), Telecommunications (TEL), transportation (TRA), and utilities (UTL).

Panel B shows that most firms belong to one of the following six industries: consumer cyclicals, financials, industrial goods and services, basic materials, technology, and consumer non-cyclicals. The number of firms in conglomerates and telecommunications is small. For Canada, the leading industries (with the most number of stocks) are basic materials and energy. For Australia, the sector of basic materials accounts for about 18% of all stocks listed. For Switzerland and Hong Kong, finance sector accounts for about a quarter of all listed firms. For Japan, the leading industries are consumer cyclicals, industrial goods and services, and financials. The same is true for UK, Germany, and France.

2.3.2. Firm characteristics

To characterize the basic features of the sample stocks within each country, Table 2 provides the summary statistics on the following variables: total market capitalization, firm size, average daily stock price, average daily number of trades, daily return volatility, and percentage quoted spreads.

Market capitalization is the product of end-of-month market value in local currencies c end-of-month exchange rate. The US-dollar denominated monthly market value is averaged over the 4-month sample period for each stock Total market capitalization is the sum of market value for all stock within each country. Firm size is the cross-sectional median among all stocks within each country. Daily stock price is calculated as the product of daily closing quote midpoints × daily exchange rate. The US-dollar denominated daily stock price is then averaged over the 48 day sample period. Average daily stock price is the cross-sectional median among all stocks within each country. Similarly, cross-sectional median of average daily number trades and daily return volatility over the 48-day sample period are summarized. Return volatility are measured by the standard deviation of daily returns calculated using midpoints. Finally, the last column of Table 2 displays the cross-sectional median of quoted percentage spreads from all stocks in each country. The intraday percentage quoted spreads are first averaged for each day. Then the daily percentage quoted spreads are averaged over the 48-day sample period. Throughout the paper, we focus on percentage quoted spreads as the quoted spreads in local currencies cannot be compared with each other.

Table 2 shows that UK has the largest total market capitalization of 2,368 billion USD in the sample countries, followed by Japan, France, Canada, and Germany. On the other hand, firm size is largest on the Virt-X, with a median market value of 4,667 million USD. Virt-X hosts the major blue chip stocks in Switzerland and Europe. With the largest number of sample stocks, the median market values are smaller for UK and Japanese firms, being 656 and 363 million USD, respectively. Regarding average stock price, a typical stock listed on the Swiss Exchange has the highest average daily price of 171.8 USD. In contrast, the typical UK and Japanese stocks have an average price of 5.4 and 7.9 USD. Korean stocks are most actively traded with a median of daily average daily number of trades exceeding 1,000. Stocks listed on Virt-X are the second most actively traded, reflecting its focus on most liquid stocks. Stocks from Iceland, Norway, Australia, and Korea are most volatile. The median daily return standard deviations for stocks in these countries all exceed 2 percent. Percentage quoted spread is the lowest on Virt-X, with a cross-sectional median of 0.15%. The percentage quoted spread is the highest 2.49% for UK stocks. Since UK contains a large sample of 532 stocks, the large percentage quoted spread mainly reflects the trading costs for relatively small capitalization stocks on the UK equity market.[7]

3. Country Factor Models

3.1 Liquidity measures

Since our focus is on international equity markets where stock prices are denominated in local currencies, naturally we estimate liquidity commonality using percentage spreads throughout the paper. Moreover, quoted spreads can be accurately measured as they are provided in the original dataset. On the other hand, measurement errors might be endemic in

[7] The trading of UK stocks are arranged as follows. The Stock Exchange Trading System (SETS) is an electronic limit order book used to trade blue-chip stocks including all FTSE 100 securities, leading FTSE 250 securities, and FTSE 100 Reserves. SETSmm is a SETS-style order book supported by market makers for FTSE 250 securities not trading on SETS, all UK FTSE Eurotop 300 securities and Exchange Traded Funds (ETFs). SEAQ is a quote-display system used as the price reference point for telephone execution between market participants and registered market makers. All domestic securities - which are not on SETS or SETSmm - with 2 or more registered market makers are traded in this manner.

effective spreads.[8] Therefore, we rely on percentage quoted spread for our empirical analysis.[9] For each stock, we first average the tick-by-tick intradaily percentage quoted spreads within the trading hours of each market to obtain a daily time-series of percentage quoted spread $L_{i,\,t}$., where i refers to stock in a particular country and t refers to the trading day, t = 1, …, 48. Then we measure the percentage change in the percentage quoted spread $DL_{i,\,t} = L_{i,\,t}/L_{i,\,t-1} - 1$ and point change in the percentage quoted spread $L_{i,\,t} - L_{i,\,t-1}$. To assure that the evidence is robust to the measurement of liquidity change, all subsequent analysis is performed for both the percentage change and point change in $L_{i,\,t}$. The empirical results are essentially the same using either measure. For brevity, the following discussions will rely on the percentage change in $L_{i,\,t}$, or $DL_{i,\,t}$.

3.2 Intraday Country Factor Model

The standard approach to estimate common variation in liquidity is the market model developed in Chordia, Roll, and Subrahmanyam (2000). The model,

$$DL_{i,\,t} = \alpha_i + \beta_i DL_{Country,\,t} + \varepsilon_{i,\,t}\,, \tag{1}$$

yields the country-liquidity beta estimate $\hat{\beta}_i$ for stock i in a particular country. $DL_{Country,\,t} = L_{Country,\,t}/L_{Country,\,t-1} - 1$ captures the percentage changes in market liquidity for that country. The country liquidity factor $L_{Country,\,t}$ is an equal or value-weighted average of individual stock

[8] Lightfoot, Martin, Peterson, and Sirri (1999) document that there can be as many as 32% biases in effective computed using the Lee and Ready (1991) algorithm.

[9] We also classify buyer- and seller-initiated transactions using the Lee and Ready (1991) algorithm to find the effective spreads. The empirical results from effective spreads are in general consistent but weaker. This might be caused by the measurement errors from classifying the transactions, which are then aggregated at a daily level.

liquidity within each country. In actual estimation, the country-wide liquidity factor used in the regression for the i-th stock excludes the liquidity of the i-th stock to minimize the cross-sectional dependence in the estimated slope coefficients. The model has been successfully applied to individual stocks using daily time-series data with observations ranging from one year to a few years.

Previous literature usually employs daily measures of liquidity variation over a 1-year period. Since our sample on average covers a short 48-day trading period, daily estimates will be less reliable. Therefore we construct intraday 15-minute liquidity measures for each of the 26 sample countries. The trading time on these 26 exchanges is typically between 4 to 9 hours, or 16 to 36 fifteen-minute intervals on each day. Therefore the corresponding number of intraday 15-minute observations range from 736 to 1,800 when trading days range from 46 to 50. The actual number of observations will be slightly different because of no-trading in some intervals. We run the intraday country factor model as in Equation (1).

Table 3 tabulates ample evidence of co-movement in intraday 15-minute liquidity variation. Since the results from equal- and value-weighted country liquidity factors are essentially the same, the following discussions will focus on the equal-weight part. The average intraday liquidity betas $\hat{\beta}_i$ ranges from a low of 0.102 for Iceland to a high of 0.980 for Japan. With the exception of Luxembourg where the sample size is only 4 (the smallest), all of the 25 average intraday liquidity betas are highly significant. The average adjusted R^2 from intraday data are much higher compared to those from daily data. The highest adjusted R^2 of 0.294 is from Korea. The last column in the equal-weight panel reports the percentage of positive and significant coefficients within each country. For the majority of the stocks in each country, or between 42.3 to 100 percent of stocks, changes in individual stock liquidity move in response to market-wide liquidity movement.

Prior studies have long established the stylized fact that intraday bid-ask spreads exhibit a significant U-shaped pattern during regular trading intervals. Bid-ask spreads tend to higher during the opening and closing sessions of each trading day. To take into account this effect, we include a dummy to allow the liquidity beta to be different during the first and last hour of the trading sessions compared to the rest of the time. Among the 26 countries, 16 coefficients are positive while 10 coefficients are negative. But none of them are significant. Therefore the liquidity betas do not increase or decrease significantly during the opening or closing sessions.

4. The Cross-Sectional Determinants of Liquidity Betas

While most of the earlier studies focus on documenting the liquidity betas from time-series regressions, they usually do not examine the cross-sectional determinants of liquidity betas, except reporting liquidity betas for stocks sorted by size quintiles. The empirical evidence is also contradicting. For example, Chordia, Roll, Subrahmanyam (2000) find liquidity betas from spread measures tend to increase with size; large firms spread have greater response to market wide changes in spreads. On the other hand, Brockman and Chung (2002) show that large firms have relatively small liquidity beta coefficients. To provide additional evidence on this issue, we adopt a regression framework that simultaneously control for other variables. The regression takes the following form in general:

$$\hat{\beta}_{\rm i} = \delta_0 + \delta_1 \ln(\text{SIZE}_{\rm i}) + \delta_2 \text{SPD}_{\rm i} + \delta_3 \ln(1+\text{NOA}_{\rm i}) + \delta_4 \text{DISP}_{\rm i} + \delta_5 \text{IWF}_{\rm i} + \sum_{\rm j=1}^{25} c_{\rm ij} \text{CDUM}_{\rm ij} + \sum_{\rm k=1}^{11} d_{\rm ik} \text{IDUM}_{\rm ik} + \varepsilon_{\rm i,\,t}, \qquad (2)$$

where the dependent variable $\hat{\beta}_i$ is the liquidity beta for stock i estimated from the intraday country factor model. The independent variables are defined as follows. SIZE is the market capitalization in U.S. dollars calculated as the average end-of-month market value over the sample period, SPD is the average percentage quoted spread, NOA is the number of analysts following each stock, DISP is earnings dispersion measured by the standard deviation of earnings estimates divided by the mean estimate[10], CDUM is the country dummy, and IDUM is the industry dummy. We also include, NUM, the average daily number of transactions in the regressions. The last variable, IWF, stands for investable weight factor.

The IWF is a floating factor constructed for all issues in the S&P/Citigroup Global Equity Index Series. The IWF ranges between 0 and 1, and accounts for the publicly available shares of a company. IWF is calculated as $1-\sum\%$ held by strategic shareholders. S&P identifies the following three types of shareholders to be strategic investors: (1) public traded corporations, venture capital firms, private equity firms, strategic partners, and leveraged buy-out groups; (2) government entities, restricted to government of domestic listing markets; (3) current and former officers of the company, directors, founders, trusts and foundations. Holdings by investors whose purposes are not strategic in nature but are for capital gains will not be deducted. These include mutual funds, pension funds, 401K plans of the company, and insurance companies, etc.[11] The last column of Table 2 summarizes the cross-sectional median level of IWF for our sample countries. For U.K. and Australia the median IWF is equal 1. For other countries the median IWF ranges from 0.21 for Luxembourg to 0.89 for Netherlands in Europe, and from 0.45 for Hong Kong to 0.68 for South Korea in Asia. Canada has a IWF equal to 0.88.

[10] Both NOA and DISP are obtained from I/B/E/S of Thomson Financials.
[11] See S&P/Citigroup Global Equity Indices Methodology.

After some experiment, we notice that the behavior of liquidity betas are significantly different between fully investable stocks (IWF=1.0) and less than fully investable stocks (IWF<1.0). Therefore we divide the full sample into two.[12] Panel A of Table 4 provides the pair-wise Pearson correlations and OLS regression results for 515 stocks that are fully investable. Intraday liquidity betas β have significantly positive correlations with ln(SIZE), ln(NUM), and ln(1+NOA), and significantly negative correlation with SPD. The correlations among ln(SIZE), ln(NUM), SPD, ln(1+NOA), and DISP are as expected. For example, number of analysts following each stock is positively correlated with firm size and trading activities but negatively correlated with bid-ask spread. Large and more actively traded firms and firms with more analysts following tend to have lower earnings dispersions. Stocks with higher bid-ask spreads tend to have higher level of earnings dispersion.

Panel A also report the OLS regression results for fully investable stocks. We can draw three conclusions for fully investable stocks. First, SIZE and NUM have reliable positive and highly significant slope coefficients. This indicates among fully investable non-U.S. developed market stocks, that larger and more actively traded issues have higher liquidity betas. They respond more to market-wide movement in liquidity. The strong result is consistent with that from Chordia, Roll, and Subrahmanyam (2000) for U.S. equity markets. Second, the coefficient on average quoted spread, SPD, is negative and highly significant. Controlling for other factors, stocks with higher percentage quoted spread tend to have low liquidity betas. In fact, the average quoted spread leads to a higher adjusted R^2 between 0.537 and 0.575 in models (1), (4) and, (7) when compared with other model specifications. The average level of the bid-ask spread provides a better explanation for the cross-sectional variation in liquidity betas. Third, the role of analysts following and earnings dispersion is limited for fully investable stocks. The log of

[12] We report the equal-weighted results. The value-weighted results are essentially the same.

one plus analysts following, ln(1+NOA), is only significant when it is used alone, used with DISP, or used with ln(SIZE). It is not significant when it is used with ln(NUM) or SPD. This is not surprising given the high correlations between them and a modest sample size of 515.

Panel B summarizes the results for less than fully investable stocks with IWF < 1.0. We notice that the correlation between liquidity beta β and ln(SIZE), ln(NUM), SPD, ln(1+NOA), DISP, and IWF are -0.054, 0.034, -0.214, -0.105, -0.073, and -0.069. All of them are highly significant except the correlation with ln(NUM) of 0.034. Noticeably, the correlation of -0.054 between liquidity beta and ln(SIZE) has become significantly negatively. So is the correlation of -0.105 between liquidity beta and ln(1+NOA). These results stand in contrast to those from fully investable stocks. In addition, for less than fully investable stocks, liquidity betas are also significantly negatively correlated with bid-ask spreads (-0.214), earnings dispersion (-0.073), and investable weight factor (-0.069).

We can draw a few conclusions from the regression results for 1932 less than fully investable stocks in Panel B. First, SIZE and NUM now have the opposite or negative sign compared to fully investable stocks. In other words, for those stocks with a relatively higher proportion of strategic investors (IWF < 1.0), who probably trade much less frequently, larger and more actively traded stocks are associated with smaller liquidity betas. Second, the negative relation between average quoted spread, SPD, and liquidity beta remains robust for less than fully investable stocks. Third, stocks with more analysts following tend to have smaller liquidity betas. Fourth, stocks with larger earnings dispersion tend to have smaller liquidity betas. Fifth, IWF has a significant and negative slope coefficient. Therefore among those less-than-fully investable stocks, more investable stocks have smaller liquidity betas.

We try to reconcile the results from fully and less than full investable stocks by relying on the story of Chordia, Roll, and Subrahmanyam (2000) for U.S. equity markets. They speculate that the fact that large firms tend to have larger liquidity betas might have something to do with the greater prevalence of institutional herding among larger firms. In our case, if institutional investors tend to herd more on large and fully investable stocks, this will lead to higher liquidity betas for large and fully investable stocks. For less than fully investable stocks, institutional investors may not show extraordinary enthusiasm in investing. The possible reasons could range from more asymmetric information to larger price impact from trading that are associated with more closely held stocks. As a result, these stocks will behave in a way conforming to our expectation, i.e., smaller stocks will response more to market wide changes in liquidity.

5. Cross-Border Liquidity Dynamics

In this section, we embark on investigating the cross-border liquidity dynamics. The issue of financial market linkage has long attracted the interest of academic researchers. Up until now the focus has been on the linkage between stock returns and return volatilities. Numerous studies have documented strong evidence of lead-lag patterns in returns or cross-border volatility transmission. However, the literature is silent on the cross-border liquidity linkage. Even with the emergence of the commonality literature, the cross-border effects have not been adequately addressed. This is due primarily to the fact that most of the commonality studies study one country at a time. In this regard, our paper attempts to fill in the gap by examining a comprehensive cross-sectional sample of developed countries.

To study the cross-border effects in liquidity, we need to look for markets where trading hours overlap. The European markets and Asian markets are the two natural candidates. There are altogether 19 countries within the European markets. Pair-wise cross-border effects among all 19 countries are not necessary. Instead, we examine the cross-border effects between the following 3 groups of countries. The first group is the major industrialized countries in Europe, i.e., United Kingdom, France, Germany, and Italy. The second group is the Euronext countries including France, Belgium, Netherlands, and Spain. The third group is the Nordic countries such as Denmark, Finland, Norway, and Sweden.[13] For the Asia-Pacific markets, we investigate pair-wise cross-border effects among the following five countries, i.e., Japan, Hong Kong, Singapore, South Korea, and Australia. Since Australia and New Zealand are closely related, we also examine the cross-border effects between these two countries.[14] Finally, we construct a liquidity factor for the S&P 500 in the U.S. and relate to liquidity factors in other exchanges where the trading hours overlap. Among the 19 European exchanges, 18 exchanges are found to have overlapping trading hours with U.S.; Greece is the only exception.[15, 16] We also study the cross-border effects between U.S. and its neighbor, Canada.

For European markets, Panels A, B, and C of Table 5 first summarize the overlapping time (GMT) and overlapping hours. Among the four major industrialized countries, the trading overlaps between 8:00 to 16:30 GMT for a total of 8.5 hours. Among the four Euronext countries, the trading also overlaps 8.5 hours from 8:00 to 16:30 GMT. Among the four Nordic countries, the trading overlaps between 6 to 8 hours. From Panels D of Table 5, the overlapping in trading in the Asian-Pacific region is shorter in general. For example, the shortest overlapping

[13] Iceland also belongs to the Nordic countries. We exclude Iceland because there does not exist any cross-border liquidity effects between Iceland and other Nordic countries' stock markets.
[14] There is no evidence of cross-border liquidity between New Zealand and other four Asian-Pacific countries and therefore the results are not reported.
[15] Luxembourg is not included because of a small sample of stocks and infrequent trading of these stocks.
[16] U.S. exchanges do not overlap with any of the six Asian-Pacific exchanges.

occurs between Japan and Hong Kong and the overlapping lasts for only 1 hour. The longest overlapping occurs between South Korea and Australia for a total of 6 hours. Panel E of Table 5 presents the overlapping of trading between U.S. and other European countries. The overlapping is short and between 0.5 to 2 hours. Trading hours in U.S. and Canada overlap for 6.5 hours from 14.30 to 21:00 GMT.

We adopt the vector auto-regression (VAR) approach to study the cross-border effects during overlapping trading hours. The VAR system incorporates two variables, the aggregate liquidity factors from the two countries under investigation. To conserve space, we focus on the equal-weighted portfolio of liquidity factors. The results from value-weighted portfolios are essentially the same. We choose the number of lags in the VAR system based on the Akaike an Schwarz information criteria. After some experimentation, we decide that a lag of 3 will be sufficient and parsimonious.[17]

Now we turn to the empirical results on cross-border effects. In Table 5, the first two number columns present the bi-directional Granger causality t-statistics and the last column presents the number of observations in the pair-wise VAR system. The Granger causality t-statistics under the column DLQ_1 test for the null hypothesis that the 1st country's liquidity factor does not Granger cause the 2nd country's liquidity factor. Likewise, the Granger causality t-statistics under the column DLQ_2 test for the null hypothesis that 2nd country's liquidity factor does not Granger cause the 1st country's liquidity factor.

A few interesting patterns appear from Table 5. First, there exist significant bi-directional causality among major industrialized countries, i.e., the United Kingdom, Germany,

[17] We also examine whether there exists bi-directional causality among individual stocks' liquidity. We select 100 most actively traded stocks from each of the 4 major industrialized countries in Europe, i.e., U.K, France, Germany, and Italy. There will be a total of 100×100 pair-wise Granger causality tests between any 2 out of these 4 countries. We summarize the median p-value for each of the 100×100 tests. The median p-values range from 0.435 to 0.700. Therefore there is no evidence of liquidity dynamics among individual stocks even among the most active and liquidity markets in Europe.

France, and Italy in Panel A. Without exception, the six pairs of Granger causality statistics are highly significant. Second, the bi-directional causality relations among four Euronext countries in Panel B are also highly significant. In particular, Euronext Paris is always associated with a larger Granger statistic when it is paired with other three Euronext countries. This indicates that Euronext Paris plays a dominate role in Euronext's liquidity dynamics. Third, the causality effect is slightly weaker among the four Nordic countries in Panel C. Nevertheless, we observe significant bi-directional causality between Denmark and Sweden, Finland and Sweden, and Norway and Sweden. The role of Swedish stock market is more important among the Nordic countries. Fourth, among the Asian-Pacific countries in Panel D, we find strong bi-directional cross-border effects between Japan and Singapore and between Singapore and Korea, where the two pairs of Granger causality statistics are both significant at the 5 percent level. There is also evidence of bi-directional cross-border effects among the following pairs of countries, i. e., Japan and South Korea, Japan and Australia, Hong Kong and Singapore, Hong Kong and South Korea, and Hong Kong and Australia. Among these countries, the cross-border effects tend to be stronger in one direction. There is no evidence of bi-directional causality between Japan and Hong Kong. One possible reason is the short overlapping of trading which lasts only one hour. There is also no evidence of bi-directional causality effects between Australia and New Zealand, although they are close neighbors. Fifth, Panel E shows that the bi-directional cross-border effects are highly significant between U.S. and France, Italy, Spain, Sweden, Switzerland, and Canada. In particular, the Granger causality statistics associated with U.S. is 55.40 compared to a smaller figure of 36.75 for Canada. The weaker bi-direction effects between U.S. and remaining countries should be interpreted with care. As we have indicated earlier, on each trading day, the overlapping between U.S. and European countries is between 0.5 to 2 hours. Our sample also only covers a short period of about 48 days on average.[18]

6. Conclusions

In this paper, we address three issues. The first one is whether there exists common variation in liquidity in international equity markets. The second is what are the cross-sectional determinants of liquidity betas. The third issue is whether there is any evidence of cross-border transmission in liquidity movements similar to the cross-border linkage in stock returns and return volatilities. The systematic variation in liquidity such as bid-ask spreads in response to a common factor has important bearing not only the expected returns of the underlying stocks, but also on the trading costs arising from allocating assets across different countries, a usual practice for virtually all institutional investors. Our sample covers a comprehensive list of S&P/Citigroup Global Equity Indices constituent stocks from virtually all developed countries. These stocks are typically highly liquid, investable at relatively low costs, and representative of the international equity markets.

For a relatively short period of 48 trading days on average, we report significant intraday common variation in liquidity. We construct 15-minute intraday liquidity factor for each stock and regress on country-specific market liquidity factor. The commonality patterns are significant for virtually all of the 26 countries except Luxembourg.

We find that the level of the bid-ask quote is the most important determinant of the liquidity betas. The higher the level of the bid-ask quote, the lower the liquidity beta. This result

[18] In Panels D and E of Table 5, since U.K. and Japan contain the largest number of stocks, many of them are relatively small and illiquid. To check the robustness of our cross-border effects, we also construct aggregate liquidity factors for FTSE 100, FTSE 250, and Nikkei 225 constituent stocks. We replace the U.K. and Japan aggregate country factors with the more liquid FTSE and Nikkei index liquidity factors. The cross-border results are essentially the same.

is robust whether the stock is fully investable or not. The role of firm size and trading activity, on the hand, depends on the level of its investability or public float. For those stocks that are 100 percent investable, we confirm similar patterns as in Chordia, Roll, and Subrahmanyam (2000) who report larger liquidity betas for larger and more actively traded stocks. For those stocks that are less than 100 percent investable, or with some proportion held by strategic investors, we find the opposite patterns. In other words, smaller and less actively traded stocks tend to have larger liquidity betas. We also discover that for less-than-fully investable stocks, liquidity betas are negatively related to the number of analysts following, earnings dispersion, and the level of investability.

We move on to investigate whether movement in liquidity factor within one country is related to that in other countries. Specifically, we focus on the following five groups of countries, i. e., major industrialized countries in Europe, Euronext countries, Nordic countries, Asia-Pacific countries, and U.S and other countries. We conclude that the cross-border effects are strongest among the major industrialized countries in European and Euronext countries, followed by Nordic countries. We also find that cross-border liquidity effects are much stronger in Europe than those in the Asian-Pacific Region. There are two possible explanations. The first is that the European exchanges are in general more open and integrated compared to exchanges in the Asian-Pacific region. The other explanation is that the overlapping trading time is longer among European exchanges than that among Asian-Pacific exchanges. Finally, we find strong evidence of cross-border effects between U.S. and Canada and between U.S. and some other countries. The relative weak results between U.S. and the remaining countries is most likely cause by both a short period of overlapping trading hours and a short sample period. To resolve this issue, much work is needed for future research in this direction.

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Table 1 Sample of the S&P-Citi Index Component Stocks

Panel A of the table summarizes the number of stocks for 26 developed countries (economies) in the S&P/Citigroup Global Equity Index System, the number of stocks that are deleted following each of the four criteria: (a) large-price stocks; (b) infrequently traded stocks; (c) stocks with significant portion of large percentage quoted spread; (4) stocks that conduct splits or changes in minimum trading units during the sample period September – December 2004. The last column contains the number of stocks in each country in the final sample. Panel B tabulates the industry distribution of the stocks in the final sample.

Panel A: Sample Stocks

Country	All Stocks in the S&P-Citi Index	Number of Large-Price Stocks	Number of Infrequently-Traded Stocks	Significant Portion of Large Quoted Spread	Number of Stock Splits or MTU changes	Final Sample
Europe						
Austria	30		6			24
Belgium	48	3				45
Denmark	54	3	5			46
Finland	71		7	1		63
France	202		2	2		198
Germany	176	2	23			151
Greece	59					59
Iceland	8		1			7
Ireland	23		3			20
Italy	151		2			149
Luxembourg	4		1			3
Netherlands	80					80
Norway	54		1			53
Pan European (Virt-X)	28					28
Portugal	21		1			20
Spain	85		2			83
Sweden	125		9			116
Switzerland	108	2	12			94
United Kingdom	571		21	18		532
Total	1898	10	96	21		1771
Asia-Pacific						
Australia	245		2	4	5	234
Hong Kong	149		2		1	146
Japan	1399	112	14	1	24	1248
New Zealand	31				2	29
Singapore	96		1			95
South Korea	191	2				189
Total	2111	114	19	5	32	1941

North America						
Canada	428	1	17	3		407
Developed World	4437	125	132	29	32	4119

Panel B: Number of Firms by Country and Industry in the Final Sample

Country	BAM	CCY	CGL	CNC	ENY	FIN	HCR	IGS	TEC	TEL	TRA	UTL
Europe												
Austria	5	2	0	0	1	6	0	5	0	1	2	2
Belgium	3	4	5	4	1	12	4	3	5	3	0	1
Denmark	2	1	1	6	0	13	7	8	2	1	5	0
Finland	8	9	1	5	1	6	2	18	10	1	2	0
France	14	50	4	20	6	33	9	27	18	3	6	8
Germany	13	25	5	8	2	27	16	29	18	2	3	3
Greece	9	12	0	5	2	11	1	11	3	2	1	2
Iceland	0	0	0	1	0	3	2	0	0	0	1	0
Ireland	2	4	1	5	0	4	2	0	0	1	1	0
Italy	13	25	2	12	4	51	3	16	3	5	2	13
Luxembourg	0	0	0	0	0	2	0	0	0	1	0	0
Netherlands	4	10	1	11	3	14	3	17	11	2	4	0
Norway	2	3	1	2	14	10	1	7	8	2	2	1
Pan European (Virt-X)	6	4	0	2	0	7	3	4	1	1	0	0
Portugal	3	4	1	1	0	3	0	1	2	2	0	3
Spain	9	14	1	8	3	16	1	14	3	4	2	8
Sweden	9	21	5	5	0	20	11	29	11	3	2	0
Switzerland	5	10	0	5	0	23	12	24	7	0	3	5
United Kingdom	32	131	2	46	22	86	26	98	42	9	22	16
Total	139	329	30	146	59	347	103	311	144	43	58	62
Asia-Pacific												
Australia	43	45	2	20	12	56	17	15	5	1	7	11
Hong Kong	8	29	15	14	4	37	3	8	11	5	7	5
Japan	128	264	10	137	19	157	58	256	146	5	47	21
New Zealand	5	6	0	2	0	4	0	1	0	1	5	5
Singapore	3	9	7	8	2	25	2	11	11	3	12	2
South Korea	22	26	5	19	4	33	4	25	36	6	6	3
Total	209	379	39	200	41	312	84	316	209	21	84	47
North America												
Canada	85	42	1	27	72	50	28	34	23	9	12	24
Developed World	433	750	70	373	172	709	215	661	376	73	154	133

Table 2 Summary Statistics

This table provides summary statistics for 4,119 stocks from 26 developed countries (economies) in the final sample. The summary statistics include the total market capitalization of the sample stocks within each country, firm size, average daily stock price, average daily number of trades, daily return volatility (standard deviation), and percentage quoted spread. Except for the total market capitalization, the numbers reported are the cross-sectional median from each country. Market capitalization is US dollar denominated using end-of-month market value in local currencies and end-month exchange rates. Daily stock prices in local currencies are adjusted by the daily exchange rates. Daily returns are calculated using closing quote midpoints. For each stock, intraday percentage quoted spreads are averaged to obtain daily observation, which are then averaged over the 48 trading day sample period. IWF ranges between 0 and 1 for each stock and accounts for the publicly available shares.

	Total Market Capitalization (billion US$)	Firm Size (Market value in million US$)	Average Daily Stock Price	Average Daily Number of Trades	Daily Return Volatility (%)	Quoted Spread (%)	IWF
Europe							
Austria	31	721	43.2	63	1.16	0.49	0.50
Belgium	122	657	53.0	76	1.11	0.43	0.59
Denmark	68	406	45.2	83	1.29	0.63	0.76
Finland	134	356	14.7	65	1.38	0.60	0.70
France	833	481	51.6	185	1.21	0.37	0.46
Germany	624	569	30.3	120	1.47	0.42	0.57
Greece	49	163	6.5	165	1.68	0.62	0.49
Iceland	6	843	0.4	44	2.41	1.06	0.60
Ireland	77	1331	13.4	27	1.45	0.97	0.83
Italy	408	489	5.3	206	1.13	0.32	0.44
Luxembourg	3	678	142.7	7	1.51	0.88	0.21
Netherlands	395	705	25.4	131	1.29	0.41	0.89
Norway	55	285	10.3	93	2.25	0.64	0.70
Pan European (Virt-X)	549	4667	79.1	994	1.25	0.15	0.85
Portugal	44	516	5.3	114	0.91	0.51	0.59
Spain	372	952	17.2	244	0.94	0.29	0.58
Sweden	234	546	14.8	91	1.38	0.53	0.78
Switzerland	58	345	171.8	29	1.18	0.67	0.63
United Kingdom	2368	656	5.4	166	1.54	2.49	1.00
Asia-Pacific							
Australia	489	557	3.0	136	2.58	0.87	1.00
Hong Kong	158	290	0.5	98	1.97	0.86	0.45
Japan	1816	363	7.9	130	1.70	0.41	0.63
New Zealand	16	315	2.8	31	1.07	0.60	0.65
Singapore	93	273	0.9	50	1.32	0.78	0.51
South Korea	225	259	14.0	1026	3.07	0.38	0.68
North America							
Canada	690	407	13.7	147	1.78	0.55	0.88

Table 3 Intraday 15-Minute Own Country Factor Model

The tables present the regression results from intraday 15-minute country factor model based on the two liquidity measures. The dependent variable is the liquidity measure from individual stock i. The independent variable, or the country factor, is the market-wide liquidity factor from the country stock i belongs to. The country factor is the proportional change in an equal-weighted or value-weighted portfolio of individual stock percentage quoted spreads. The country factor excludes the liquidity from stock i in the regression for stock i. The table reports the average slope coefficient from regressions within each country, the cross-sectional t-statistics, the average adjusted R^2, and the percentage of positive and significant coefficients. The t-statistics are adjusted for the cross-correlations in the residuals of individual stock regressions by a factor of $[1+(N-1)\rho]^{0.5}$, where ρ is proxied by the average of residual correlations from adjacent individual stock regressions.

	Equal Weighted				Value Weighted			
	Own Country Factor	T-statistics	Average Adj. R^2	Percentage Positive Significant	Own Country Factor	T-statistics	Average Adj. R^2	Percentage Positive Significant
European								
Austria	0.318	9.43**	0.038	91.3	0.408	11.03**	0.048	95.7
Belgium	0.253	5.30**	0.015	64.4	0.481	7.46**	0.050	71.1
Denmark	0.551	10.56**	0.124	100.0	0.823	12.71**	0.137	100.0
Finland	0.332	11.15**	0.049	92.1	0.568	14.47**	0.066	95.2
France	0.289	16.66**	0.010	57.1	0.407	12.47**	0.018	57.1
Germany	0.546	5.40**	0.061	80.1	0.612	7.66**	0.094	78.1
Greece	0.707	9.01**	0.144	98.3	0.993	10.55**	0.148	100.0
Iceland	0.102	4.41**	0.013	42.9	0.078	4.47**	0.010	57.1
Ireland	0.527	17.82**	0.141	100.0	0.444	16.52**	0.142	100.0
Italy	0.413	9.77**	0.076	87.2	1.510	13.88**	0.103	87.2
Luxembourg	0.386	1.37	0.346	66.6	0.102	1.33	0.414	66.6
Netherlands	0.549	7.93**	0.041	93.8	0.865	13.93**	0.072	95.0
Norway	0.414	8.33**	0.073	90.6	1.006	15.22**	0.087	96.2
Pan European	0.467	4.80**	0.082	100.0	1.486	6.09**	0.097	100.0
Portugal	0.315	4.52**	0.013	75.0	0.802	7.12**	0.027	70.0
Spain	0.769	9.89**	0.059	90.4	1.120	69.34**	0.082	91.6
Sweden	0.159	5.59**	0.004	64.5	0.354	4.67**	0.004	63.9
Switzerland	0.383	11.17**	0.017	83.0	0.371	10.96**	0.020	84.0
United Kingdom	0.650	22.06**	0.112	66.4	0.538	20.47**	0.134	66.4
Asia Pacific								
Australia	0.333	11.90**	0.009	62.8	0.192	9.15**	0.011	57.3
Hong Kong	0.446	6.11**	0.042	78.8	0.826	7.72**	0.044	82.2
Japan	0.980	10.98**	0.170	96.1	1.596	11.28**	0.169	96.0
New Zealand	0.121	4.47**	0.010	63.8	0.103	4.48**	0.009	64.1
Singapore	0.731	8.87**	0.085	88.4	1.165	5.01**	0.061	86.3
South Korea	0.490	18.11**	0.294	100.0	0.441	16.72**	0.284	99.5
North American								
Canada	0.899	20.63**	0.054	96.1	0.910	28.25**	0.060	96.1

Table 4 The Cross-Sectional Determinants of Own Country Liquidity Betas

Panels A and B summarizes the Pearson correlations and OLS regressions of liquidity betas for fully investable and less-than-fully investable stocks, respectively. The table first presents the Pearson correlations among the following variables: the estimated intraday day liquidity beta (β), the log of firm size (SIZE), the log number of trades (NUM), average percentage quoted spread over the sample period (SPD), the log of one plus the number of analysts (NOA) following each stock, scaled earnings dispersion (DISP), the log of Morck, Yeung, and Yu (2000) or MYY measure, investable weight factor (IWF). Then the table presents the OLS regressions of liquidity betas obtained from 15-minute intraday country factor model on the above variables plus country dummies (CDUM) and industry dummies (IDUM). Robust t-statistics are in parentheses below the estimates. * indicates significance at the 10 percent level; ** indicates significance at the 5 percent level.

Panel A: Pearson Correlations for Fully Investable Stocks, IWF = 1.0

	β	ln(SIZE)	Ln (NUM)	SPD	ln(1+NOA)	DISP	ln(MYY)	IWF
β	1.000	0.420**	0.569**	-0.448**	0.252**	-0.019	-0.021	–
ln(SIZE)		1.000	0.844**	-0.545**	0.679**	-0.139**	-0.257**	–
Ln(NUM)			1.000	-0.583**	0.647**	-0.028	-0.220**	–
SPD				1.000	-0.601**	0.145**	0.205**	–
Ln(1+NOA)					1.000	-0.092**	-0.270**	–
DISP						1.000	0.035	–
Ln(MYY)							1.000	–
IWF								1.000

Panel B: Pearson Correlations for Less than Fully Investable Stocks, IWF < 1.0

	β	ln(SIZE)	ln (NUM)	SPD	ln(1+NOA)	DISP	ln(MYY)	IWF
β	1.000	-0.054**	0.034	-0.214**	-0.105**	-0.073**	-0.068**	-0.069**
ln(SIZE)		1.000	0.771**	-0.410**	0.671**	-0.020	-0.384**	0.342**
ln(NUM)			1.000	-0.477**	0.602**	0.022	-0.358**	0.211**
SPD				1.000	-0.361**	0.031	0.289**	-0.002
ln(1+NOA)					1.000	-0.022	-0.216**	0.130**
DISP						1.000	-0.041*	0.026
ln(MYY)							1.000	-0.146**
IWF								1.000

Panel C: OLS Regressions of Liquidity Betas, IWF = 1.0

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.447	-2.591	-3.150	0.050	-0.743	-0.792	0.620	-0.403
	(1.28)	(-6.34)**	(-9.32)**	(0.44)	(-7.10)**	(-7.98)**	(5.58)**	(-3.37)**
ln(SIZE)	0.011	0.131	0.170					
	(0.68)	(5.61)**	(10.86)**					
ln(NUM)				0.097	0.229	0.214		
				(6.59)**	(13.35)**	(17.10)**		
SPD × 100	-0.281			-0.207			-0.282	
	(-15.74)**			(-11.50)**			(-16.96)**	
ln(1+NOA)		0.126			-0.067		0.026	0.385
		(2.10)**			(-1.39)		(0.67)	(9.56)**
DISP			0.071			-0.013		0.047
			(1.00)			(-0.22)		(0.65)
ln(MYY)			-0.003			0.062		
			(-0.03)			(0.59)		
CDUM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IDUM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	515	515	515	515	515	515	515	515
Adjusted R^2	0.538	0.305	0.299	0.575	0.460	0.458	0.537	0.261

Panel D: OLS Regressions of Liquidity Betas, IWF < 1.0

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	2.146	2.045	1.007	1.104	0.849	0.995
	(10.02)**	(9.40)**	(12.51)**	(13.17)**	(12.39)**	(13.22)**
ln(SIZE)	-0.072	-0.062				
	(-6.38)**	(-5.14)**				
ln(NUM)			-0.042	-0.033		
			(-3.71)**	(-2.93)**		
SPD × 100	-0.326	-0.323	-0.324	-0.321	-0.288	-0.292
	(-16.04)**	(-15.87)**	(-14.82)**	(-14.68)**	(-14.66)**	(-14.92)**
ln(1+NOA)	-0.017	-0.023	-0.072	-0.068	-0.113	-0.099
	(-0.71)	(-0.95)	(-3.34)**	(-3.17)**	(-6.12)**	(-5.34)**
DISP	-0.038	-0.037	-0.034	-0.032	-0.037	-0.034
	(-2.41)**	(-2.30)**	(-2.12)**	(-2.02)**	(-2.28)**	(-2.13)**
ln(MYY)	0.284	0.281	0.333	0.317	0.380	0.351
	(5.29)**	(5.23)**	(6.24)**	(5.94)**	(7.28)**	(6.71)**
IWF		-0.141		-0.207		-0.236
		(-2.60)**		(-3.97)**		(-4.57)**
CDUM	Yes	Yes	Yes	Yes	Yes	Yes
IDUM	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1932	1932	1932	1932	1932	1932
Adjusted R^2	0.343	0.345	0.334	0.339	0.329	0.336

Table 5 Neighboring Country Intraday Liquidity Betas

The tables present the regression results from intraday 15-minute own country and neighboring countries' liquidity factor model. The dependent variables is the liquidity factor from individual stock i. The two independent variables are the own country factor and neighboring countries' liquidity factor. The country factor excludes the liquidity from stock i in the regression for stock i. For each country, the table only reports the average slope coefficient of the liquidity betas on neighboring countries' factor, the cross-sectional t-statistics, the average adjusted R^2, and the percentage of positive and significant coefficients. The t-statistics are adjusted for the cross-correlations in the residuals of individual stock regressions by a factor of $[1+(N-1)\rho]^{0.5}$, where ρ is proxied by the average of residual correlations from adjacent individual stock regressions.

	Equal Weighted				Value Weighted			
	Neighboring Country Factor	T-statistics	Average Adj. R^2	Percentage Positive Significant	Neighboring Country Factor	T-statistics	Average Adj. R^2	Percentage Positive Significant
European								
Austria	-0.019	-0.83	0.036	0.0	-0.108	-1.88	0.046	0.0
Belgium	0.876	6.12**	0.039	64.4	0.538	6.77**	0.054	42.2
Denmark	-0.041	-2.08	0.001	2.2	-0.033	-1.68	0.000	0.0
Finland	0.000	-0.03	0.000	3.2	-0.014	-0.61	0.003	1.6
France	0.195	2.47**	0.006	37.4	0.160	5.03**	0.014	25.3
Germany	0.543	6.94**	0.069	70.2	0.326	5.97**	0.094	27.8
Greece	-0.060	-1.77	0.143	0.0	-0.230	-1.90	0.147	0.0
Iceland	-0.164	-1.41	0.012	0.0	0.010	0.07	0.009	0.0
Ireland	0.828	10.36**	0.187	90.0	0.654	10.12**	0.192	95.0
Italy	0.211	6.46**	0.078	48.3	0.146	4.21**	0.103	39.6
Luxembourg	0.809	0.55	0.108	0.0	-0.961	-0.35	-0.291	0.0
Netherlands	0.379	5.15**	0.048	50.0	0.177	4.56**	0.074	27.5
Norway	-0.016	-0.62	0.074	3.8	-0.021	-0.95	0.088	3.8
Pan European	0.699	4.62**	0.108	92.9	0.126	2.49**	0.100	32.1
Portugal	0.384	5.21**	0.049	80.0	0.277	5.11**	0.058	75.0
Spain	0.271	5.50**	0.061	49.4	0.155	4.74**	0.082	21.7
Sweden	0.001	0.08	0.001	4.3	0.002	0.22	0.001	0.9
Switzerland	0.757	11.32**	0.027	73.4	0.220	3.08**	0.019	17.0
United Kingdom	0.143	11.45**	0.104	34.2	0.219	5.02**	0.120	8.6
Asia Pacific								
Australia	0.013	0.92	0.008	3.4	0.005	0.22	0.013	5.1
Hong Kong	0.039	0.93	0.043	3.4	0.077	1.14	0.046	6.8
Japan	-0.023	-1.08	0.176	9.1	-0.025	-1.29	0.175	6.6
New Zealand	-0.006	-0.16	0.022	10.3	-0.009	-0.07	0.009	3.4
Singapore	-0.049	-1.28	0.113	4.2	-0.066	-0.86	0.085	2.1
South Korea	-0.011	-1.11	0.163	3.7	0.023	1.55	0.175	13.2
North American								
Canada	0.230	11.94**	0.059	49.9	0.122	7.95**	0.061	21.4

Table 6 The Cross-Sectional Determinants of Neighboring Country Liquidity Betas

Panels A and B summarizes the Pearson correlations and OLS regressions of neighboring country liquidity betas for fully investable and less-than-fully investable stocks, respectively. Panel A presents the Pearson correlations between the estimated intraday day neighboring country liquidity beta (β) and the following variables, the log of firm size (SIZE), the log number of trades (NUM), average percentage quoted spread over the sample period (SPD), the log of one plus the number of analysts (NOA) following each stock, scaled earnings dispersion (DISP), the log of Morck, Yeung, and Yu (2000) or MYY measure, investable weight factor (IWF). Panel B reports the OLS regressions of neighboring country liquidity betas on the above variables plus country dummies (CDUM) and industry dummies (IDUM). Robust t-statistics are in parentheses below the estimates. * indicates significance at the 10 percent level; ** indicates significance at the 5 percent level.

Panel A: Pearson Correlations

	ln(SIZE)	Ln (NUM)	SPD	ln(1+NOA)	DISP	ln(MYY)	IWF
β, Fully Investable, IWF = 1.0	0.251**	0.240**	-0.327**	0.263**	-0.013	-0.108*	–
β, Less than Fully Investable, IWF < 1.0	0.160**	0.124**	-0.115**	0.205**	-0.003	0.139**	-0.016

Panel B: OLS Regressions of Neighboring Country Liquidity Betas

	Fully Investable Stocks, IWF = 1.0		Less than Fully Investable Stocks, IWF < 1.0	
Intercept	0.372	0.057	-0.258	-0.055
	(1.63)	(0.78)	(-2.15)**	(-1.19)
ln(SIZE)	-0.016		0.018	
	(-1.29)		(2.64)**	
ln(NUM)		0.009		0.028
		(0.86)		(4.56)**
SPD × 100	-0.079	-0.068	-0.071	-0.055
	(-7.47)**	(-6.12)**	(-6.29)**	(-4.60)**
ln(1+NOA)	0.034	0.001	0.032	0.027
	(1.19)	(0.01)	(2.43)**	(2.28)**
DISP	0.034	0.032	-0.003	-0.006
	(1.01)	(0.94)	(-0.37)	(-0.64)
ln(MYY)	-0.016	-0.002	0.081	0.089
	(-0.28)	(-0.03)	(2.75)**	(3.07)**
IWF	-	-	-0.043	-0.040
			(-1.43)	(-1.40)
CDUM	Yes	Yes	Yes	Yes
IDUM	Yes	Yes	Yes	Yes
Observations	518	518	1981	1981
Adjusted R^2	0.510	0.508	0.532	0.535

Table 7 Cross-Border Liquidity Effects

The table analyzes the cross-border liquidity effects between the following five groups of countries: major industrialized countries in Europe, the Euronext countries, the Nordic countries, the Asia-Pacific countries, the U.S. and other countries. The cross-border liquidity effects are examined using a vector autoregression framework. The two endogenous variables are the equal-weighted liquidity factors from the two corresponding countries. Using intraday 15-minute liquidity measures, the VAR is estimated with a lag of 3 during overlapping trading hours. The table reports the pair-wise Granger causality t-statistics between the two endogenous variables, overlapping time (GMT), overlapping hours, and number of observations (Obs) employed in the VAR system. * indicates significance at the 10 percent level; ** indicates significance at the 5 percent level.

Panel A: Major Industrialized Countries in Europe

Country 1	Country 2	DLQ_1	DLQ_2	Overlapping Time (GMT)	Overlapping Hours	Obs
United Kingdom	France	146.81**	98.82**	8:00-16:30	8.5	1598
United Kingdom	Germany	106.05**	60.58**	8:00-16:30	8.5	1628
United Kingdom	Italy	11.25**	42.13**	8:00-16:30	8.5	1589
France	Germany	249.95**	9.41**	8:00-16:30	8.5	1666
France	Italy	28.29**	81.28**	8:00-16:30	8.5	1657
Germany	Italy	31.32**	89.71**	8:00-16:30	8.5	1657

Panel B: Euronext Countries

Country 1	Country 2	DLQ_1	DLQ_2	Overlapping Time (GMT)	Overlapping Hours	Obs
France	Belgium	43.75**	66.33**	8:00-16:30	8.5	1632
France	Netherlands	71.95**	165.28**	8:00-16:30	8.5	1632
France	Spain	87.07**	156.19**	8:00-16:30	8.5	1530
Belgium	Netherlands	12.49**	21.67**	8:00-16:30	8.5	1598
Belgium	Spain	20.33**	19.14**	8:00-16:30	8.5	1496
Netherlands	Spain	39.13**	16.37**	8:00-16:30	8.5	1564

Panel C: Nordic Countries

Country 1	Country 2	DLQ_1	DLQ_2	Overlapping Time (GMT)	Overlapping Hours	Obs
Denmark	Finland	22.79**	5.54	8:00-16:00	8.0	1543
Denmark	Norway	1.62	13.52**	9:00-15:00	6.0	1117
Denmark	Sweden	11.31**	11.54**	8:30-16:00	7.5	1371
Finland	Norway	2.64	11.96**	9:00-15:00	6.0	1117
Finland	Sweden	17.44**	8.22**	8:30-16:30	8.0	1461
Norway	Sweden	18.37**	14.15**	9:00-15:00	6.0	1128

Panel D: Asia-Pacific Countries

Country 1	Country 2	DLQ_1	DLQ_2	Overlapping Time (GMT)	Overlapping Hours	Obs
Japan	Hong Kong	5.28	4.45	3:30-4:30	1.0	168
Japan	Singapore	9.33**	27.06**	1:00-2:00, 3:30-4:30	2.0	352
Japan	South Korea	6.49*	21.17**	0:00-2:00, 3:30-6:00	4.5	774
Japan	Australia	8.46**	6.52*	0:00-2:00, 3:30-6:00	4.5	726
Hong Kong	Singapore	7.49*	13.17**	2:00-4:30, 6:30-8:00	4.0	704
Hong Kong	South Korea	6.91*	9.28**	2:00-4:30	2.5	430
Hong Kong	Australia	22.48**	7.65*	2:00-4:30	2.5	460
Singapore	South Korea	15.67**	10.03**	1:00-4:30	3.5	630
Singapore	Australia	4.38	5.38	1:00-4:30	3.5	658
South Korea	Australia	4.87	3.41	0:00-6:00	6.0	988
Australia	New Zealand	1.99	3.29	0:00-5:00	5.0	775

Pane E: US and Other Countries

Country 1	Country 2	DLQ_1	DLQ_2	Overlapping Time (GMT)	Overlapping Hours	Obs
United States	Austria	1.17	6.55*	14:30-16:30	2.0	360
United States	Belgium	9.21*	12.81**	14:30-16:30	2.0	376
United States	Denmark	3.12	4.59	14:30-16:00	1.5	282
United States	Finland	4.14	8.35*	14:30-16:30	2.0	376
United States	France	20.13**	13.45**	14:30-16:30	2.0	384
United States	Germany	6.62*	0.15	14:30-16:30	2.0	872
United States	Iceland	13.55**	0.42	14:30-16:00	1.5	286
United States	Ireland	1.73	15.37**	14:30-16:30	2.0	384
United States	Italy	113.83**	99.75**	14:30-16:30	2.0	384
United States	Netherlands	6.25*	32.34**	14:30-16:30	2.0	384
United States	Norway	1.76	2.95	14:30-15:00	0.5	96
United States	Pan European	0.56	26.98**	14:30-16:30	2.0	376
United States	Portugal	6.31*	8.16**	14:30-16:30	2.0	384
United States	Spain	18.24**	19.74**	14:30-16:30	2.0	368
United States	Sweden	12.48**	226.97**	14:30-16:30	2.0	368
United States	Switzerland	17.45**	93.87**	14:30-16:30	2.0	376
United States	United Kingdom	4.47	4.52	14:30-16:30	2.0	384
United States	Canada	55.40**	36.75**	14:30-21:00	6.5	1195